

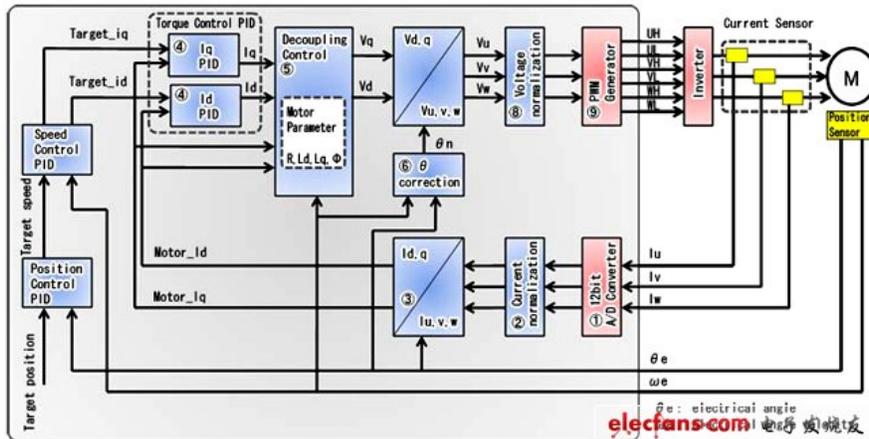
Microcontroller Applications and Its Principle

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■ Block diagram



Warm hints: The word in this article is about 3200 and reading time is about 20 minutes.

Summary

A microcontroller is a single chip microcomputer that integrates the main parts of a microcomputer on a chip. The microcontroller was born in the middle of 1970s. After 20 years of development, its cost is becoming lower and its performance is more and more powerful, which makes its application everywhere and in all fields. For example, motor control, bar code reader / scanners, consumer electronics, game devices, telephone, HVAC, building safety and access control, industrial control and automation, and white household appliances (washing machines, microwave ovens). This paper is mainly introduce the microcontroller applications and working principels including microcontroller types; the differences between microcontroller and microprocessor; or top microcontroller manufacturers in the world and etc.

Article core	Microcontroller Applications and Its Principle	Author	Kamal.R.
English name	Microcontroller	Category	Microcontroller
Born in	Mid 1970s		

Catalogs

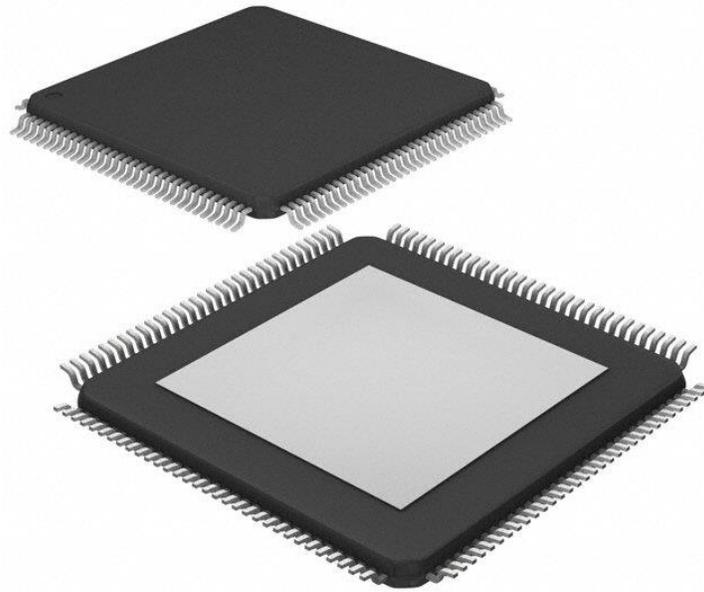
Catalogs	I.Microcontroller Introduction	Pin Description of 8051 Microcontroller	Application Field
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	II. Microcontroller Features	Renesas Microcontroller	Instruction Set Feature
	III. Microcontroller Types	IV. Microcontroller Applications	VI. Top Ten Microcontroller manufacturers in the world
	Microcontroller 8051	V. Microcontroller vs Microprocessor	
	Memory Architecture of 8051	Hardware Structure	

Introduction

I. Microcontroller Introduction

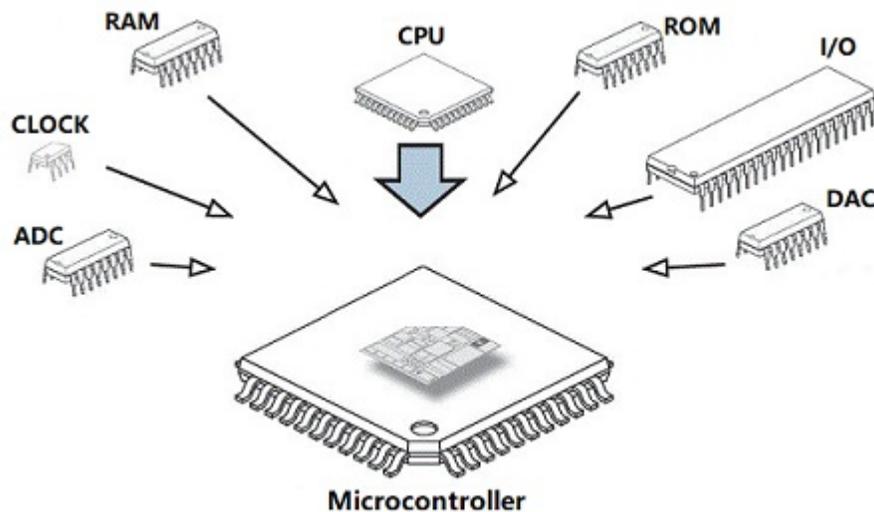
A microcontroller is a single chip microcomputer that integrates the main parts of a microcomputer on a chip. The microcontroller was born in the middle of 1970s. After 20 years of development, its cost is becoming lower and its performance is more and more powerful, which makes its application everywhere and in all fields. For example, motor control, bar code reader / scanners, consumer electronics, game devices, telephone, HVAC, building safety and access control, industrial control and automation, and white household appliances (washing machines, microwave ovens). Well, according to wiki, a microcontroller (or MCU for microcontroller unit) is a small computer on a single integrated circuit. In modern terminology, it is similar to, but less sophisticated than, a system on a chip or SoC; an SoC may include a microcontroller as one of its components. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Program memory in the form of ferroelectric RAM, NOR flash or OTP ROM is also often included on chip, as well as a small amount of RAM. Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips. Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems.



II. Microcontroller Features

Microcontroller have several main features as following:

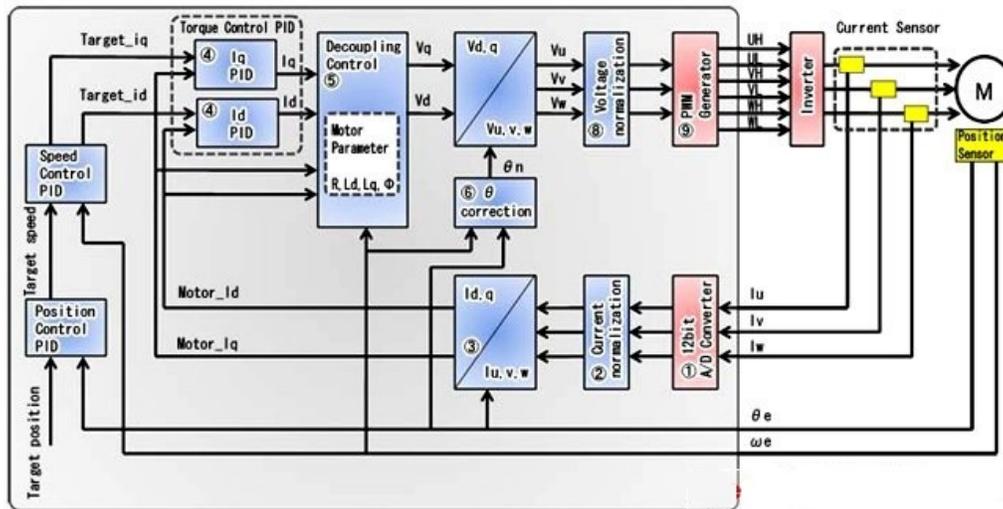
(1) The reliability is good. Because all kinds of functional components of micro controller are integrated on a chip, especially memory is integrated into the chip, the wiring is short, the data are mostly transferred inside the chip, it is not easy to be subjected to external interference, enhance the anti-interference ability, and make the system run more reliably. Therefore, the reliability is obviously superior to the general general CPU system.



(2) Strong control function. In order to meet the requirements of industrial control, the instruction system of general microcontrollers has a wealth of conditional branching transfer instructions, logical operation and bit processing function of I/O port. In general, the logic control function and running speed of the microcontroller are higher than the CPU of the same level.

(3) Easy to expand. There are many three buses and parallel, serial input / output pins for extension, and it is easy to form a computer application system of various sizes.

■ Block Diagram



(4) There is no monitoring program or system management software in the general microcontroller, and the development needs the corresponding simulation system.

III. Microcontroller Types

The microcontrollers can be divided into two major categories: ordinary singlechip and digital signal processing single chip microcomputer (DSP).

According to the word length, the common singlechip at present is from 4 to 32. The function is strong and weak, suitable for different occasions. Most of the world's largest semiconductor companies have their own microcontrollers.

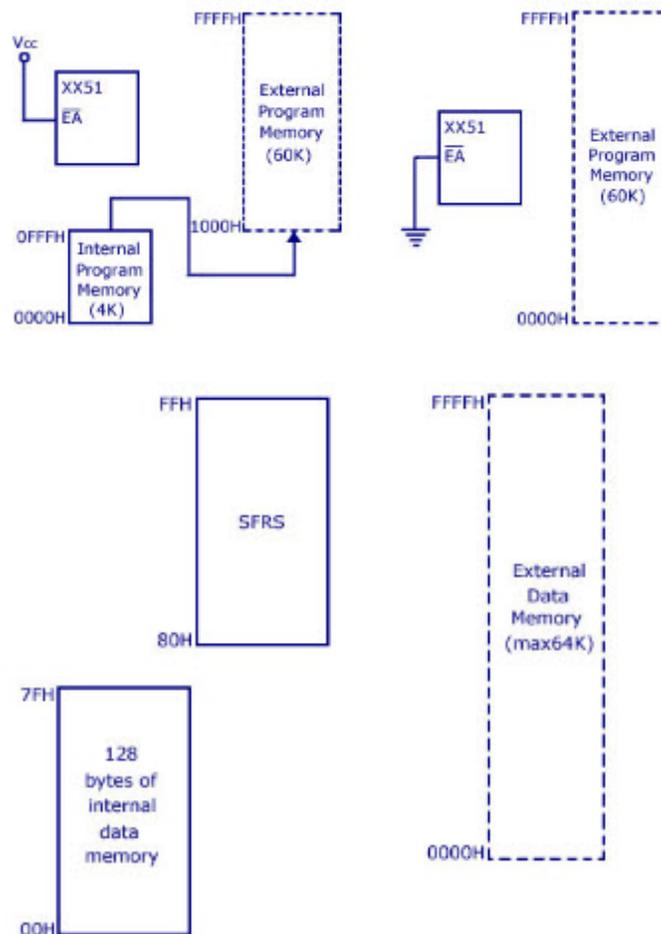
Microcontroller 8051

It is a 40pin microcontroller with Vcc of 5V connected to pin 40 and Vss at pin 20 which is kept 0V. And there are input and output ports from P1.0 – P1.7 and which having open drain feature. Port3 has got extra features. Pin36 has open drain condition and pin17 has internally pulled up transistor inside the microcontroller. When we apply logic 1 at port1 then we get logic 1 at port21 and vice versa. The programming of microcontroller is dead complicate. Basically we write a program in C-language which is next converted to machine language understand by the microcontroller. A RESET pin is connected to pin9, connected with a capacitor. When the switch is ON, the capacitor starts charging and RST is high. Applying a high to the reset pin resets the microcontroller. If we apply logic zero to this pin, the program starts execution from the beginning.



Memory Architecture of 8051

The memory of 8051 is divided to two parts. They are Program Memory and Data Memory. Program Memory stores the program being executed whereas Data Memory temporarily stores the data and the results. The 8051 has been in use in a wide number of devices, mainly because it is easy to integrate into a device. Microcontrollers are mainly used in energy management, touch screen, automobiles, and medical devices. Just see the following pictures:



Pin Description of 8051 Microcontroller

- Pin-40: Vcc is the main power source of +5V DC.
- Pin 20: Vss – it represents ground (0 V) connection.
- Pins 32-39: Known as Port 0 (P0.0 to P0.7) to serving as I/O ports.
- Pin-31: Address Latch Enable (ALE) is used to demultiplex the address-data signal of port 0.
- Pin-30: (EA) External Access input is used to enable or disable external memory interfacing. If there is no external memory requirement, this pin is always held high.
- Pin- 29: Program Store Enable (PSEN) is used to read signal from external program memory.
- Pins- 21-28: Known as Port 2 (P 2.0 to P 2.7) – in addition to serving as I/O port, higher order address bus signals are multiplexed with this quasi bi directional port.
- Pins 18 and 19: Used to interfacing an external crystal to provide system clock.
- Pins 10 – 17: This port also serves some other functions like interrupts, timer input, control signals for external memory interfacing Read and Write. This is a quasi bidirectional port with internal pull up.
- Pin 9: It is a RESET pin, used to set the 8051 microcontroller to its initial values, while the microcontroller is working or at the initial start of application. The RESET pin must be set high for 2 machine cycles.
- Pins 1 – 8: This port does not serve any other functions. Port 1 is a quasi bi directional I/O port.

Renesas Microcontroller

Renesas is latest automotive microcontroller family that offers high performance feature with exceptionally low power consumption over a wide and versatile extend of items. This microcontroller offers rich functional security and embedded safety characteristics required for new and advanced automotive applications. The core structure of microcontroller CPU support high reliability and high performance requirements. The Renesas microcontroller offering low power, high performance, modest packages and the largest range of memory sizes combined together with characteristics rich peripherals.



Renesas offers the most versatile microcontroller families in the world for example our RX family offers a many types devices with memory variants from 32K flash/4K RAM to an incredible 8M flash/512K RAM. The RX Family of 32-bit microcontrollers is a feature rich, general purpose MCU covering a wide range of embedded control applications with high speed connectivity, digital signal processing and inverter control. The RX microcontroller family uses a 32-bit enhanced Harvard CISC architecture to achieve very high performance.

Detail

IV. Microcontroller Applications

Just see the video below firstly:



This video is about " Microprocessors and Microcontrollers " talked by Prof. Ajit Pal, Dept of Computer Science & Engg., IIT Kharagpur, it is relevant to the following contents.

The hardware and software design and configuration scale of the microcontroller application system is based on the functional requirements of the application system, and has the best performance price ratio. After the use of microcontrollers, many hardware circuits can be implemented by software (called softening of hardware), which can greatly reduce the hardware structure of the system. This can reduce the cost, on the other hand, it also greatly improves the reliability of the system. The application system of micro controller has the characteristics of small size, low power consumption, strong function and high reliability.

The micro controller has been widely used in various fields, such as household appliances, office equipment, measurement and control system, intelligent instrument, communication system and mechanical and electrical industry. With the advent of cheap microcontroller, its application will be more and more extensive.

- (1) **Mechatronics products.** The combination of micro controller and traditional mechanical products makes the structure of traditional mechanical products simplified, intelligent control, and the human-machine interface is more friendly, forming a new generation of mechanical and electrical integration products. Such as micro controller controlled knitting machine, CNC machine tool and so on.
- (2) **Intelligent instrument and instrument.** With the transformation of micro controller measurement and control instrument of the original, promoted the instrument to digital, intelligent, multi-functional, integrated and flexible development, make the instrument with automatic range selection, automatic error correction, self diagnosis, data protection and other functions. The measuring, processing and controlling functions of the instrument set, which is composed of the micro controller, endow the measuring instrument and instrument with a new look.
- (3) **Measurement and control system.** A variety of industrial control systems, adaptive control systems, data acquisition systems, such as automatic control of electroplating production line, are made up of microcontrollers.

- (4) Intelligent computer peripherals. Microcontrollers are used, such as plotter and hard disk drive. The needle printer is controlled by two microcontrollers. The keyboard of a microcomputer is controlled by a microcontroller.
- (5) Intelligent sensor. The combination of the micro controller and the sensor constitutes the intelligent sensor, which can easily realize the nonlinear correction.
- (6) Communication systems

Analysis

V. Microcontroller vs Microprocessor

The differences of Microcontroller and microprocessor are mainly concentrated in three aspects: hardware structure, application field and instruction set feature.

Hardware Structure

The microprocessor is a single-chip CPU, and the microcontroller integrates CPU and other circuits in an integrated circuit chip, forming a complete microcomputer system. In addition to CPU, the microcontroller also includes RAM, ROM, a serial interface, a parallel interface, a timer, and an interrupt scheduling circuit. These are integrated on an integrated circuit. Although the capacity of the RAM on chip is smaller than the ordinary microcomputer system, this does not limit the use of the microcontroller. It can be learned from the back that the application of the microcontroller is very wide.

An important feature of the microcontroller is the built - in interrupt system. As a control oriented device, the microcontroller often responds to external excitation (interruption) in real time. A micro controller must perform a fast context switch and hang one process to execute another process to respond to an "event". For example, opening the door of a microwave oven is an event, and this event will trigger an interruption in a product based on the microcontroller. Microprocessor can also have strong interrupt function, but usually requires external components to cooperate, and microcontrollers integrate all the circuits necessary to process interrupts on the chip.

Application Field

Microprocessors are usually used as CPU in a microcomputer system. Its design is aimed at such an application, which is also the advantage of the microprocessor. However, microcontrollers are usually used for control - oriented applications. Its system design seeks miniaturization and reduces the number of components as much as possible. In the past, these applications often need to be implemented with dozens or even hundreds of digital integrated circuits. The use of microcontroller can reduce the number of components. Only one microcontroller, a few external components and control programs stored in ROM can achieve the same function. Microcontroller is suitable for occasions where input and output devices are controlled by very few components, and microprocessor is suitable for information processing in computer system.

Instruction Set Feature

Because of the different applications, the instruction set of microcontrollers and microprocessors is also different. The instruction set of the microprocessor enhanced the processing function to enable it to have powerful addressing modes and instructions suitable for operating large-scale data. The instructions of a microprocessor can operate on half bytes, bytes, words, or even double words. By using address pointers and address offsets, the microprocessor provides an access mode that can access a large number of data. Self augmented and self subtraction patterns make it easy to access data in byte, word, or double word units. In addition, the microprocessor has other features, such as the failure to use privileged instructions in the user's program. The instruction set of the microcontroller is applicable to the input / output control. Many input / output interfaces are single / bit. For example, the electromagnet controls the switch of the motor, and the electromagnet is controlled by a 1 - bit output port. The microcontroller has instructions for setting and clearing units, and also performs other bit oriented operations, such as logical and / or XOR operations on bits, jumping based on flag bits, etc. Few microprocessors have these powerful bit operation capabilities, because when designing microprocessors, designers only consider byte or larger units to operate data.

In terms of device control and monitoring (possibly through a 1 bit interface), the microcontroller has special internal circuits and instructions for input / output, timing and external interrupt priority assignment. In general, microprocessors need to cooperate with additional circuits (serial interface chips, interrupt controllers, timers, etc.) to perform the same task. However, simple processing capacity, the microcontroller will never reach the microprocessor level (in the same condition), because a large part of the integrated circuit microcontroller chip for the realization of other on-chip functions, at the cost of sacrifice part processing ability.

Because the resource on the microchip is very tight, its instructions must be very streamlined, and most of the instructions are shorter than 1 bytes. The design principle of control program is usually that the program can be loaded on the chip ROM, because even adding 1 external ROM will significantly improve the hardware cost of the product. The basic feature of the instruction set of the microcontroller is the simplification of the coding scheme. Microprocessors do not have such features, because their powerful addressing mode makes instruction coding short.

VI. Top Ten Microcontroller manufacturers in the world

Manufacturers	Logo	Description
Texas Instruments		Considered to be the best leading manufacturer and supplier of MSP430, which is a low power 16-bit Flash microcontroller. It also supplies other devices like telecom products involving RF, wireless, and analog integrated circuits.
Microchip Company		Engaged in the production and supply of several varieties of 8-microcontroller families consisting of configurations like PIC18, PIC16, and PIC12. It also offers the most popular PIC24, which is 16-bit microcontrollers.
Silicon Labs		It is found that the product C8051Fxxx offered by this

	 <p>SILICON LABS</p>	<p>company belongs to a family of quick, flash type mixed signal of 8051 microcontrollers.</p>
<p>Dallas Semiconductor</p>		<p>A high performance flash type 8051 microcontroller device is manufactured by Dallas Semiconductor Company. It also offers secure type of 8051 microcontrollers containing a watch battery in order to keep alive SRAM function.</p>
<p>Renesas Technology Corp</p>		<p>This Japanese company is a leading producer of microcontroller products. Its collection of microcontroller products comprises R32C, M16C, R8C, SuperH and H8. In addition, the company offers smart card type microcontrollers to the global market.</p>
<p>STMicroelectronics</p>		<p>A 32bit arm based microcontrollers, 8-bit ST6 and STM8 microcontroller devices and the uPSD3200 8051-compatible microcontroller are some of the products manufactured and supplied by this company. In addition, the company provides adequate customer support through online training courses. The products are especially designed to meet the requirements of broadcasting industry.</p>
<p>Intel Corporation</p>		<p>Intel is one of the popular manufacturers engaged in the production and supply of Pentium personal computer micro processors. It also produces microcontrollers and is a leading supplier of PC chipsets, mother boards and several other computer peripherals.</p>
<p>Fujitsu Semiconductor Europe</p>		<p>This company acts as an important and leading supplier of semiconductor products comprising microcontroller's devices throughout the regions of Africa, the Middle East and Europe. It offers several varieties of microcontroller devices with advanced design parameters.</p>
<p>ZiLog Company</p>		<p>This company is a pioneer in the production and supply of microcontroller devices. Its entire product portfolio of flash microcontrollers include Z8 low power microcontroller containing a rich peripheral configuration, eZ80 embedded Ethernet group of microcontrollers accompanied by flash and free RTOs.</p>
<p>Freescale Semiconductor</p>		<p>This is one among the world's best producers and suppliers of both analog and digital semiconductor devices. The company's entire product portfolio of microcontrollers ranges from 8 bit to 32 bit configuration. The list of microcontroller products includes DSP56800, PowerPC, MCore, Coldfire, 68040, 68030, 68020, 68000, 68HC11 and 68HC908.</p>

Book Recommendation

- Microcontroller Theory and Applications with the PIC18F

This book presents the fundamental concepts of assembly language programming and interfacing techniques associated with typical microcontrollers. As part of the second edition's revisions, PIC18F assembly language and C programming are provided in separate sections so that these topics can be covered independent of each other if desired. This extensively updated edition includes a number of fundamental topics. Characteristics and principles common to typical microcontrollers are emphasized. Interfacing techniques associated with a basic microcontroller such as the PIC18F are demonstrated from chip level via examples using the simplest possible devices, such as switches, LEDs, Seven-Segment displays, and the hexadecimal keyboard. In addition, interfacing the PIC18F with other devices such as LCD displays, ADC, and DAC is also included. Furthermore, topics such as CCP (Capture, Compare, PWM) and Serial I/O using C along with simple examples are also provided.

--M. Rafiquzzaman (Author)

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