Tishk International University
Mechatronics Engineering Department
Microcontroller and Programming
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Microcontroller and Programming

Dr. Rand Basil Alhashimie

Email: rand.basil@tiu.edu.iq

Outline

- Introduction to Microcontroller
- The difference between Microcontroller and Microprocessor
- 8051 Microcontroller

What is Microcontroller?

- A Microcontroller is a programmable digital processor with necessary peripherals. Both microcontrollers and microprocessors are complex sequential digital circuits meant to carry out job according to the program / instructions. Sometimes analog input/output interface makes a part of microcontroller circuit of mixed mode(both analog and digital nature).

What is the difference between Microcontroller and Microprocessor?

1. A microprocessor requires an external memory for program/data storage. Instruction execution requires movement of data from the external memory to the microprocessor or vice versa. Usually, microprocessors have good computing power and they have higher clock speed to facilitate faster computation.
2. A microcontroller has required on-chip memory with associated peripherals. A microcontroller can be thought of a microprocessor with inbuilt peripherals.
3. A microcontroller does not require much additional interfacing ICs for operation and it functions as a stand alone system. The operation of a microcontroller is multipurpose, just like a Swiss knife.
4. Microcontrollers are also called embedded controllers. A microcontroller clock speed is limited only to a few tens of MHz. Microcontrollers are numerous and many of them are application specific.

What is the difference between Microcontroller and Microprocessor?

- We use more number of microcontrollers compared to microprocessors. Microprocessors are primarily used for computational purpose, whereas microcontrollers find wide application in devices needing real time processing / control.
- Application of microcontrollers are numerous. Starting from domestic applications such as in washing machines, TVs, air conditioners, microcontrollers are used in automobiles, process control industries , cell phones, electrical drives, robotics and in space applications.

Development of Microcontroller:

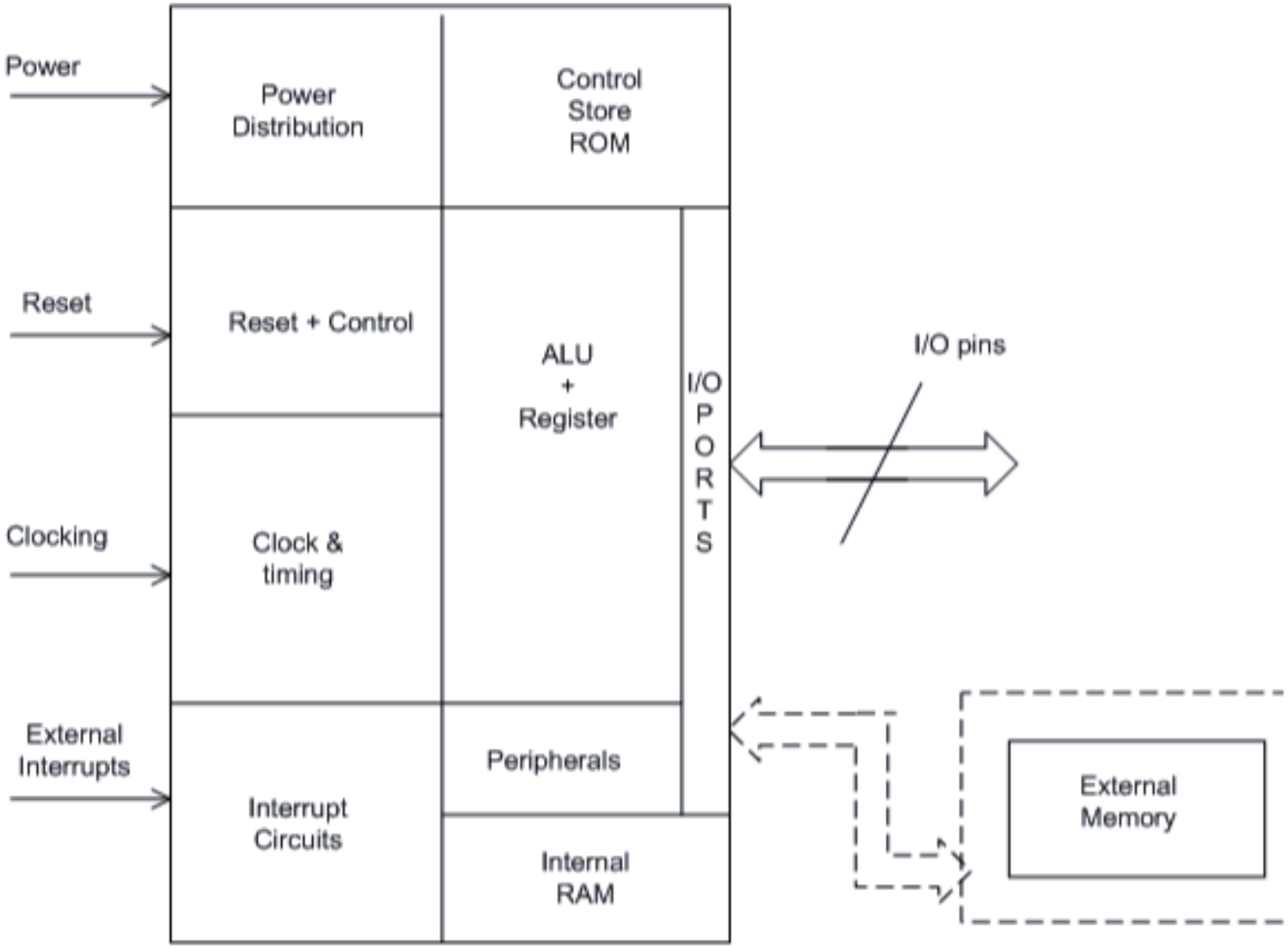
Microcontrollers have gone through a silent evolution (invisible). The evolution can be rightly termed as silent as the impact or application of a microcontroller is not well known to a common user, although microcontroller technology has undergone significant change since early 1970's. Development of some popular microcontrollers is given as follows.

Intel 4004	4 bit (2300 PMOS trans, 108 kHz)	1971
Intel 8048	8 bit	1976
Intel 8031	8 bit (ROM-less)	
Intel 8051	8 bit (Mask ROM)	1980
Microchip PIC16C64	8 bit	1985
Motorola 68HC11	8 bit (on chip ADC)	
Intel 80C196	16 bit	1982
Atmel AT89C51	8 bit (Flash memory)	
Microchip PIC 16F877	8 bit (Flash memory + ADC)	

Microcontroller Chip

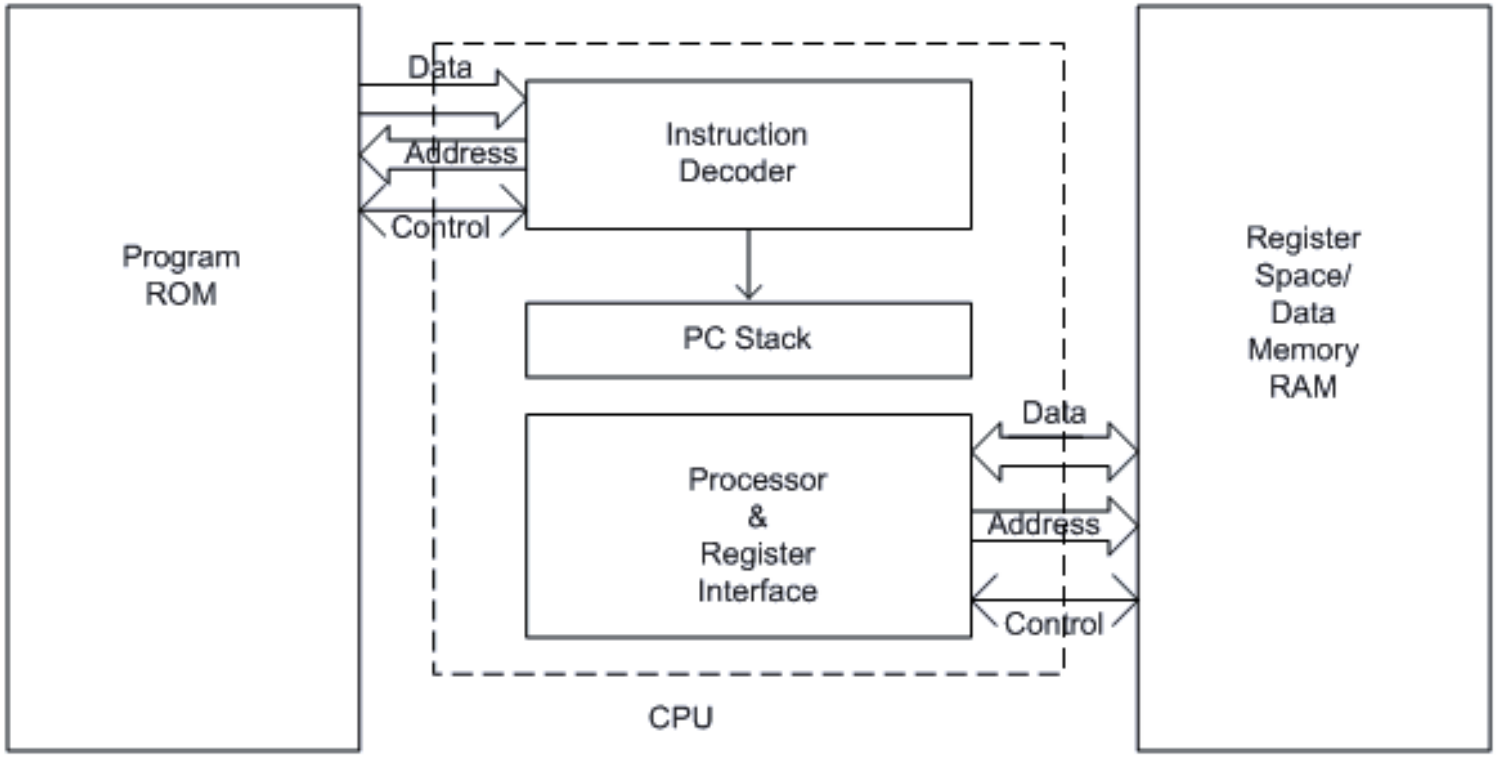
- Broad Classification of different microcontroller chips could be as follows:
  - Embedded (Self -Contained) 8 - bit Microcontroller
  - 16 to 32 Microcontrollers
  - Digital Signal Processors
- Features of Modern Microcontrollers
  - Built-in Monitor Program
  - Built-in Program Memory
  - Interrupts
  - Analog I/O
  - Serial I/O
  - Facility to Interface External Memory
  - Timers

Internal Structure of Microcontroller



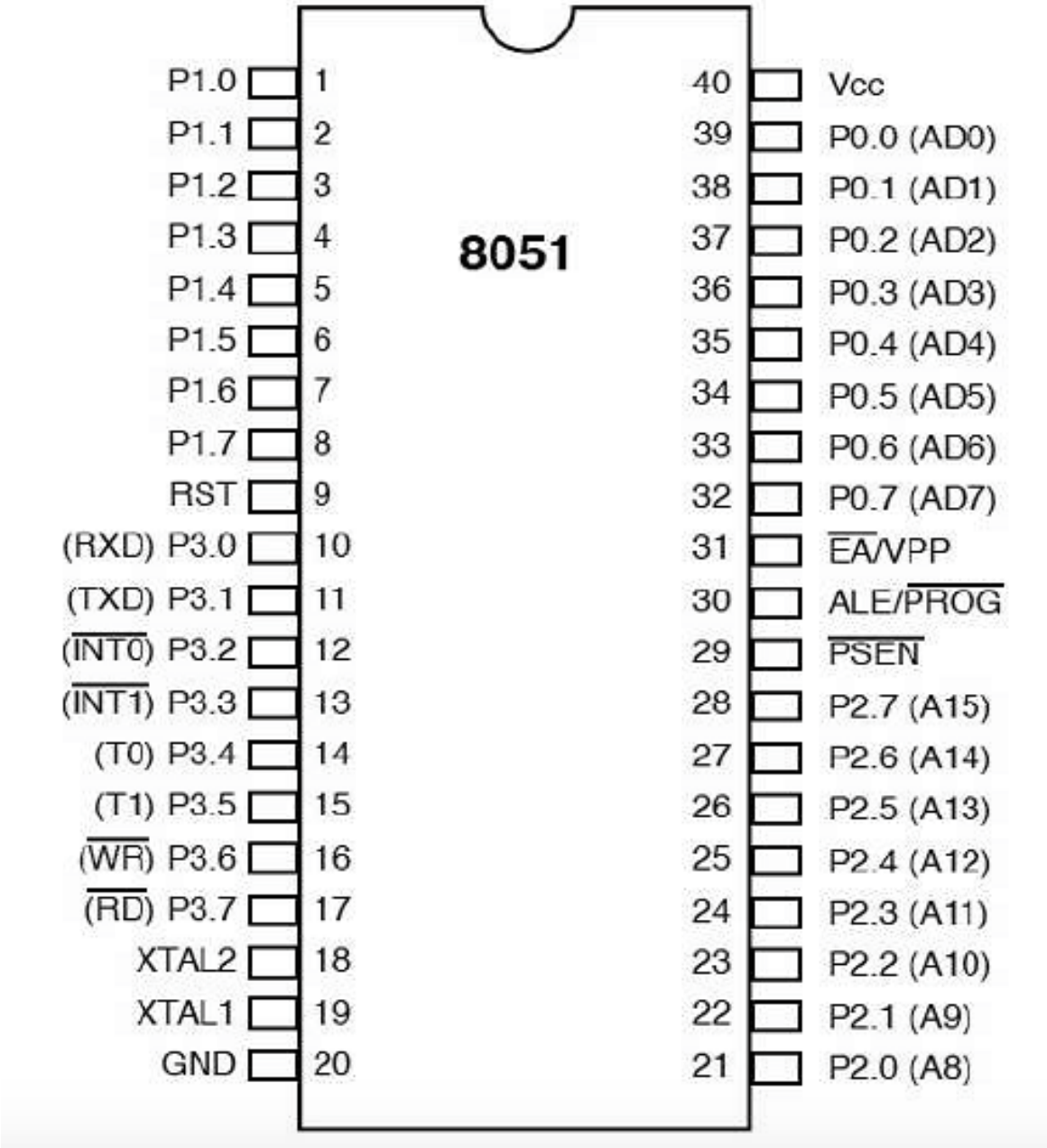
Hardware Architecture of Microcontroller

At times, a microcontroller can have external memory also (if there is no internal memory or extra memory interface is required). Early microcontrollers were manufactured using bipolar or NMOS technologies. Most modern microcontrollers are manufactured with CMOS technology, which leads to reduction in size and power loss. Current drawn by the IC is also reduced considerably from 10mA to a few micro Amperes in sleep mode (for a microcontroller running typically at a clock speed of 20MHz).



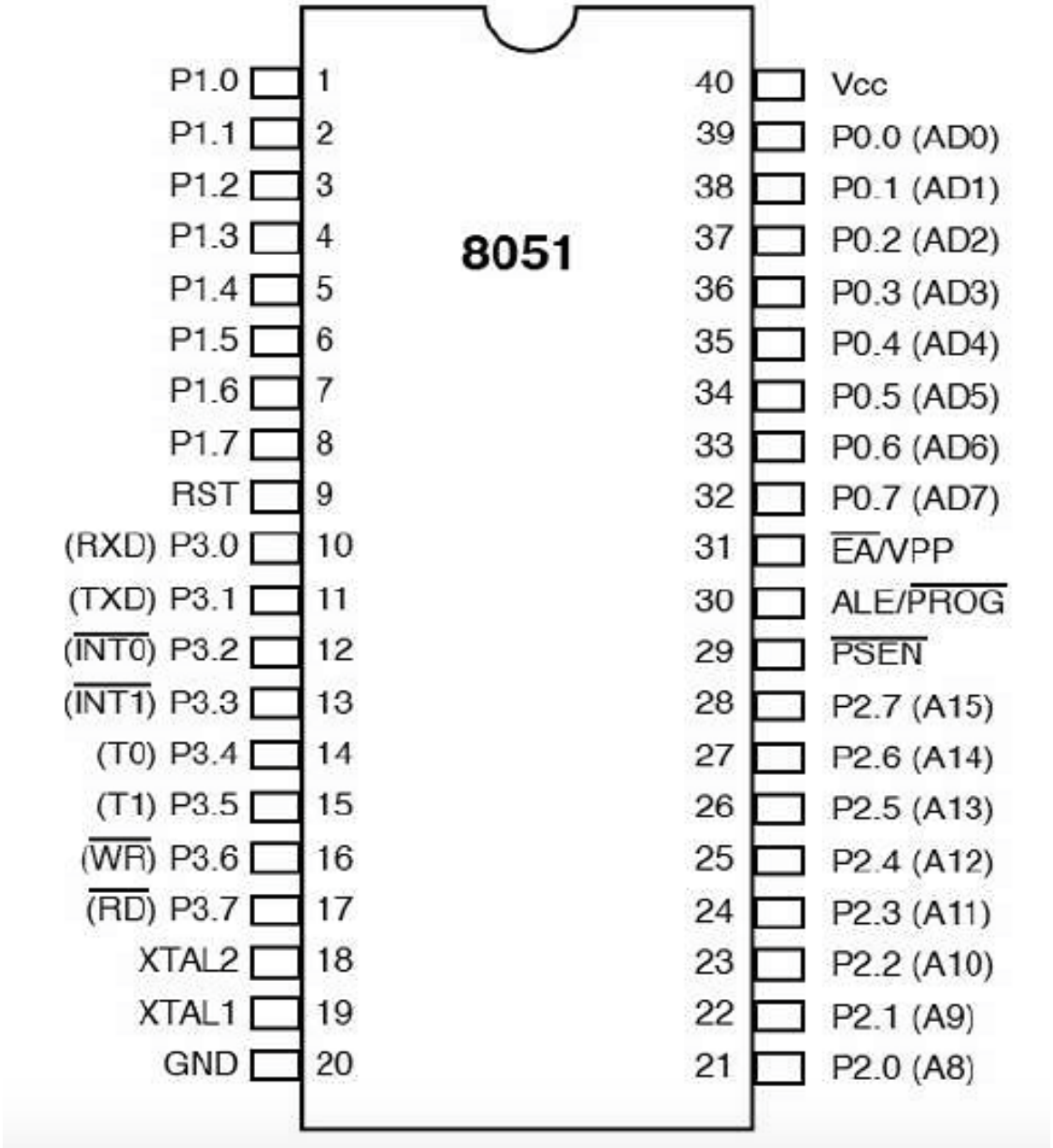
8051 Microcontroller

8051 microcontroller is designed by Intel in 1981. It is an 8-bit microcontroller. It is built with 40 pins DIP (dual inline package), 4kb of ROM storage and 128 bytes of RAM storage, 2 16-bit timers. It consists of four parallel 8-bit ports, which are programmable as well as addressable as per the requirement. An on-chip crystal oscillator is integrated in the microcontroller having crystal frequency of 12 MHz.



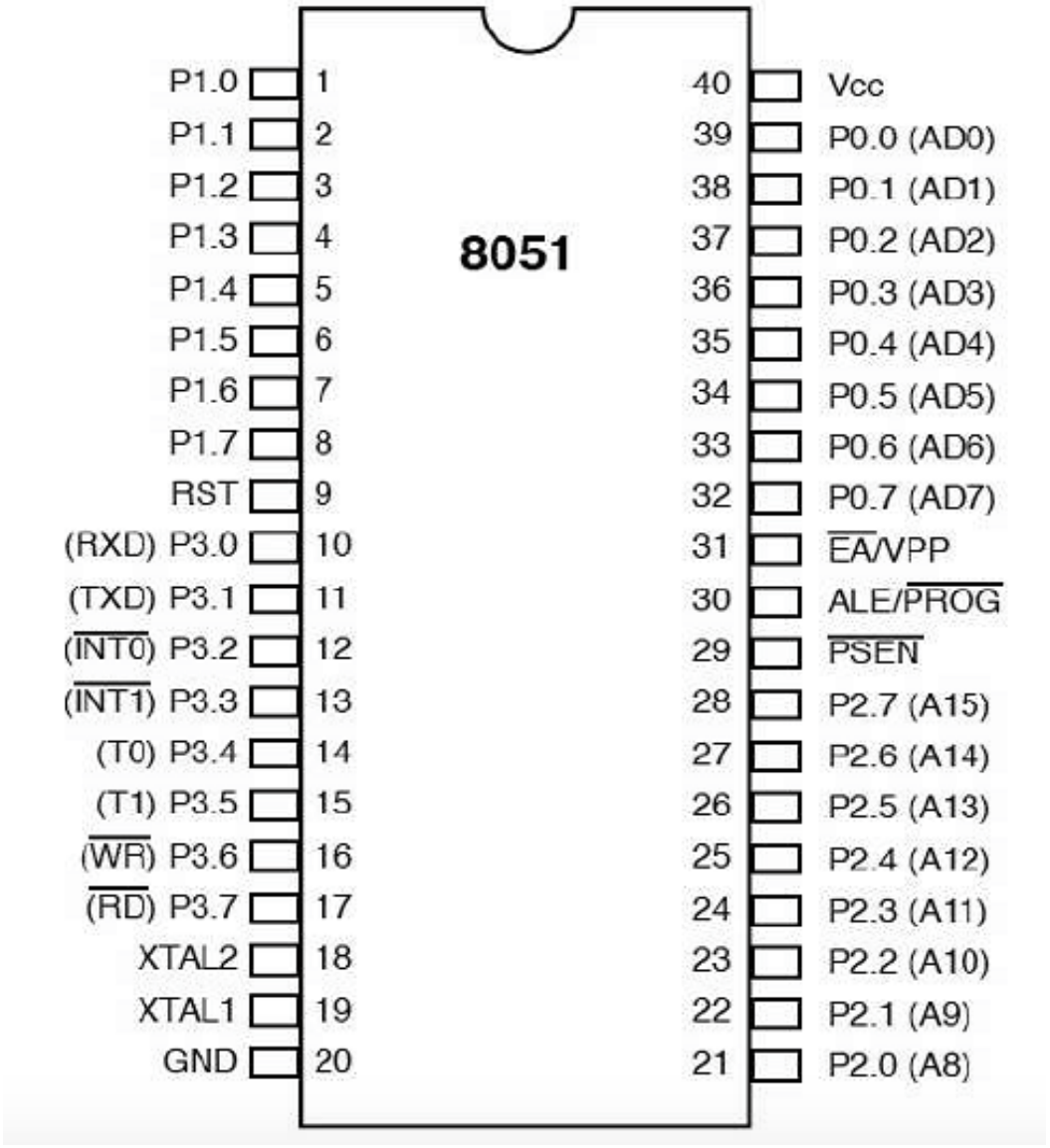
8051 Microcontroller

- Pins 1 to 8 − These pins are known as Port 1. This port doesn't serve any other functions. It is internally pulled up, bi-directional I/O port.
- Pin 9 − It is a RESET pin, which is used to reset the microcontroller to its initial values.
- Pins 10 to 17 − These pins are known as Port 3. This port serves some functions like interrupts, timer input, control signals, serial communication signals RxD and TxD, etc.
- Pins 18 & 19 − These pins are used for interfacing an external crystal to get the system clock.
- Pin 20 − This pin provides the power supply to the circuit.



8051 Microcontroller

- Pins 21 to 28 − These pins are known as Port 2. It serves as I/O port. Higher order address bus signals are also multiplexed using this port.
- Pin 29 − This is PSEN pin which stands for Program Store Enable. It is used to read a signal from the external program memory.
- Pin 30 − This is EA pin which stands for External Access input. It is used to enable/disable the external memory interfacing.
- Pin 31 − This is ALE pin which stands for Address Latch Enable. It is used to demultiplex the address-data signal of port.
- Pins 32 to 39 − These pins are known as Port 0. It serves as I/O port. Lower order address and data bus signals are multiplexed using this port.
- Pin 40 − This pin is used to provide power supply to the circuit.



8051 Microcontroller

8051 microcontrollers have 4 I/O ports each of 8-bit, which can be configured as input or output. Hence, total 32 input/output pins allow the microcontroller to be connected with the peripheral devices.

- Pin configuration, i.e. the pin can be configured as 1 for input and 0 for output as per the logic state.
  - Input/Output (I/O) pin − All the circuits within the microcontroller must be connected to one of its pins except P0 port because it does not have pull-up resistors built-in.
  - Input pin − Logic 1 is applied to a bit of the P register. The output FE transistor is turned off and the other pin remains connected to the power supply voltage over a pull-up resistor of high resistance.
- Port 0 − The P0 (zero) port is characterized by two functions −
  - When the external memory is used then the lower address byte (addresses A0A7) is applied on it, else all bits of this port are configured as input/output.
  - When P0 port is configured as an output then other ports consisting of pins with built-in pull-up resistor connected by its end to 5V power supply, the pins of this port have this resistor left out.

8051 Microcontroller

Input Configuration

If any pin of this port is configured as an input, then it acts as if it “floats”, i.e. the input has unlimited input resistance and in-determined potential.

Output Configuration

When the pin is configured as an output, then it acts as an “open drain”. By applying logic 0 to a port bit, the appropriate pin will be connected to ground (0V), and applying logic 1, the external output will keep on “floating”.

In order to apply logic 1 (5V) on this output pin, it is necessary to build an external pullup resistor.

Port 1

P1 is a true I/O port as it doesn’t have any alternative functions as in P0, but this port can be configured as general I/O only. It has a built-in pull-up resistor and is completely compatible with TTL circuits.

Port 2

P2 is similar to P0 when the external memory is used. Pins of this port occupy addresses intended for the external memory chip. This port can be used for higher address byte with addresses A8-A15. When no memory is added then this port can be used as a general input/output port similar to Port 1.

8051 Microcontroller

Port 3

In this port, functions are similar to other ports except that the logic 1 must be applied to appropriate bit of the P3 register.

Pins Current Limitations

- When pins are configured as an output (i.e. logic 0), then the single port pins can receive a current of 10mA.
- When these pins are configured as inputs (i.e. logic 1), then built-in pull-up resistors provide very weak current, but can activate up to 4 TTL inputs of LS series.
- If all 8 bits of a port are active, then the total current must be limited to 15mA (port P0: 26mA).
- If all ports (32 bits) are active, then the total maximum current must be limited to 71mA.