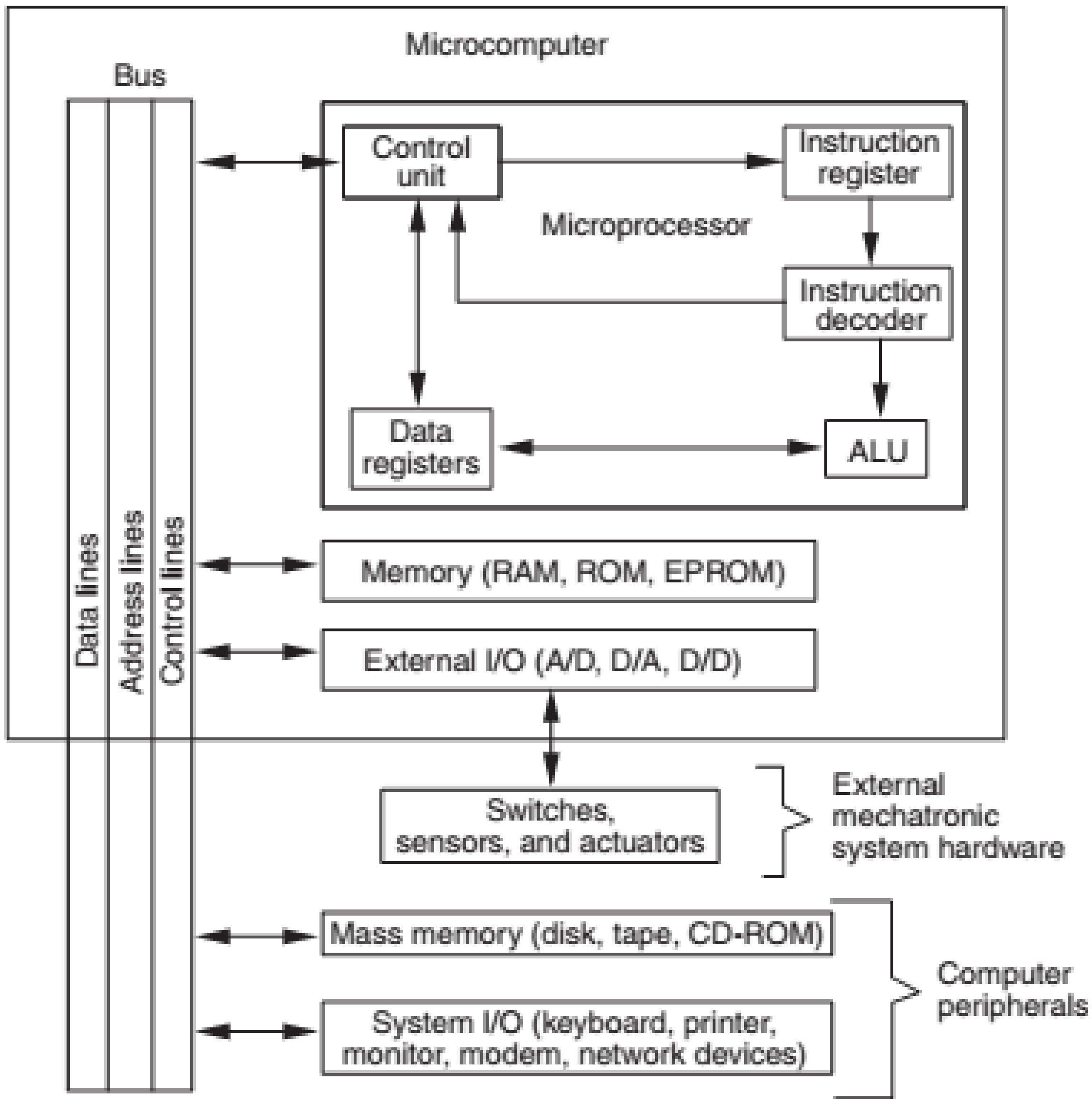
Microcomputer Architecture



A microprocessor is a single, very-large-scale-integration (VLSI) chip that contains many digital circuits that perform arithmetic, logic, communication, and control functions.

When a microprocessor is packaged on a printed circuit board with other components, such as interface and memory chips, the resulting assembly is referred to as a microcomputer or single-board computer.

The microprocessor, also called the central processing unit (CPU) or microprocessor unit (MPU)

High-level languages: Programs can also be written in a higher-level language such as BASIC or C, provided that a compiler is available that can generate machine code for the specific microprocessor being used.

The advantages of using a high-level language are:

- ease of learning and use;
- ease of debugging programs (the process of finding and removing errors);
- ease of comprehension of programs;

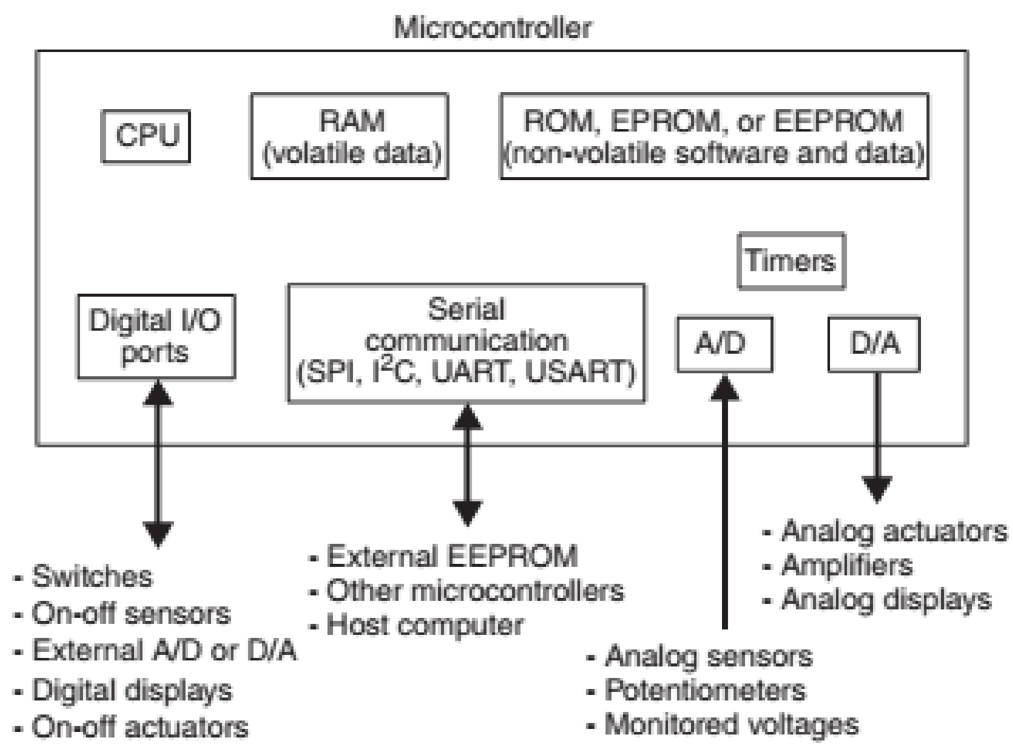
Disadvantages include

- the resulting machine code may be less efficient (i.e. slower and require more memory) than a corresponding well-written assembly language program;
- consumption of more EEPROM space.

The microcontroller contains a microprocessor, memory, I/O capabilities, and other on-chip resources. It is basically a microcomputer on a single IC.

Popular microcontrollers that have being in great demand for realizing mechatronics systems are:

Microchip's PIC;
Motorola's 68HC11; and
Intel's 8096.



The components of a microcontroller are the:

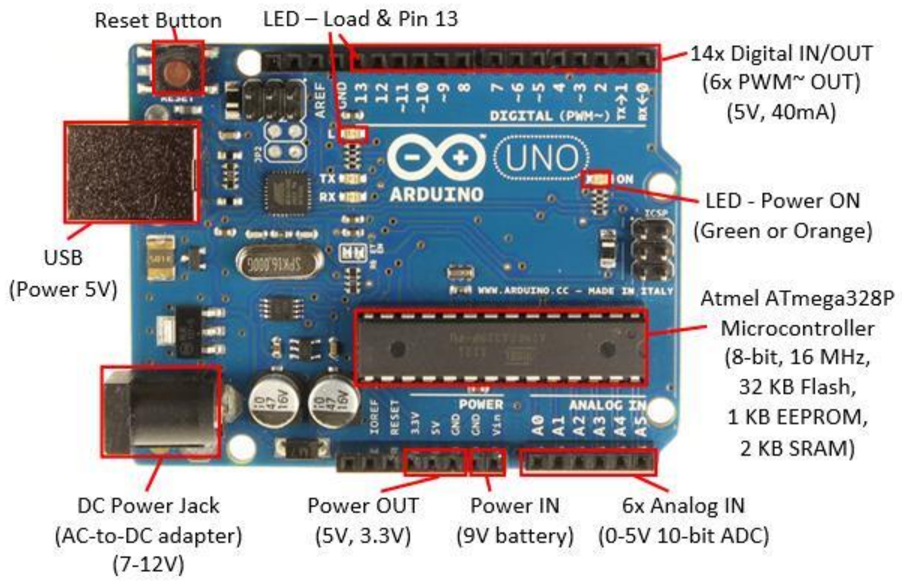
- CPU

RAM

- ROM
- Digital I/O ports
- A serial communication interface
- Timers
- Analog-to-digital (A/D) converters, and digital-to-analog (D/A) converters

Features of the Arduino UNO:

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328)
- Electrically Erasable Programmable Read-Only Memory (EEPROM): 1 KB (ATmega328)
- Clock Speed: 16 MHz



For an amplifier system it is customary to talk of the *gain* of the amplifier. This states how much bigger the output signal will be when compared with the input signal. It enables the output to be determined for specific inputs Thus, for example, an amplifier with a voltage gain of 10 will give, for an input voltage of 2 mV, an output of 20 mV, or if the input is 1 V an output of 10 V The gain states the mathematical relationship between the output and the input for the block

$$\text{Gain} = \frac{\text{output}}{\text{input}}$$

However, for many systems the relationship between the output and the input is in the form of a differential equation and so a statement of the function as just a simple number like the gain of 10 is not possible. We cannot just divide the output by the input because the relationship is a differential equation and not a simple algebraic equation. We can, however, transform a differential equation into an algebraic equation by using what is termed the *Laplace transform*. Differential equations describe how systems behave with time and are transformed by means of the Laplace transform into simple algebraic equations, not involving time, where we can carry out normal algebraic manipulations of the quantities. We talk of behaviour in the *time domain* being transformed to the *s-domain*. Then we can define the relationship between output and input in terms of a *transfer function*. The transfer function states the relationship between the Laplace transform of the output and the Laplace transform of the input, i.e.

$$\text{Transfer function} = \frac{\text{Laplace transform of output}}{\text{Laplace transform of input}}$$

We can indicate when a signal is in the time domain, i.e. is a function of time, by writing it as $f(t)$. When in the s-domain a function is written, since it is a function of s, as $F(s)$. It is usual to use a capital letter F for the Laplace transform and a lower-case letter f for the time-varying function $f(t)$.

Suppose that the input to a linear system has a Laplace transform of $Y(s)$ and the Laplace transform of the output is $X(s)$. The *transfer function* $G(s)$ of the system is then defined as

$$G(s) = \frac{X(s)}{Y(s)}$$

To obtain the Laplace transform of a differential equation which includes quantities which are functions of time we can use tables coupled with a few basic rules (Appendix A includes such a table and gives details of the rules). Figure 11.2 shows basic transforms for common forms of inputs.

	Time function $f(t)$	Laplace transform $F(s)$
1	$\delta(t)$, unit impulse	1
2	$\delta(t-T)$, delayed unit impulse	e^{-sT}
3	$u(t)$, a unit step	$\frac{1}{s}$
4	$u(t-T)$, a delayed unit step	$\frac{e^{-sT}}{s}$
5	t, a unit ramp	$\frac{1}{s^2}$
	$\sin \omega t$, a sine wave	$\frac{\omega}{s^2+\omega^2}$
	$\cos \omega t$, a cosine wave	$\frac{s}{s^2+\omega^2}$