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Micro controllers

4.1) Introduction

⇒ Micro controllers are widely used for control applications in Vehicles, toys, appliances & telecommunication device.

↳ Micro controllers are also called embedded controllers.

4.2) Numbering System

★ **Decimal System**

↳ base 10

↳ Numbers are represented as a combination of any of the base 10 digits that are used.

$$763 = (7\times10^2)+(6\times10^1)+(3\times10^0)$$

→ Convenient for scientific maths but not convenient in Computer system.

★ **Binary System**

↳ Base 2 System uses two digits (0 & 1) to represent numbers.

↳ Similar to how data is stored inside the computer.

$$10110 \Rightarrow (1\times2^4)+(0\times2^3)+(1\times2^2)+(1\times2^1)+(0\times2^0)$$
$$= 22 \text{ (in decimal)}$$

Represent the decimal number 59 in binary form.

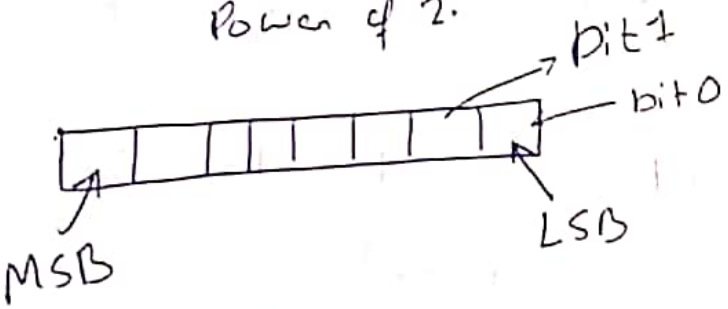
2	59	
2	29	1
2	14	1
2	7	0
2	3	1
	1	1

$\Longrightarrow (59)_{10} = (111011)_2$

⇒ The Smallest unit of storage in a Computer System is the bit.
↳ (0 or 1)

⇒ byte ⟶ group of 8 bit

⇒ When dealing with binary numbers :-
→ The rightmost bit of the binary number is called the Least Significant bit (LSB).
↳ Sience it represents the Smallest Power of 2.
→ The Leftmost bit is called most significant bit (MSB)
↳ Sience it represents the largest Power of 2.



★ Hexadecimal System

⇒ When evaluating the Contents of a large memory location it is more Convenient if we can write the values of each ~~digit~~ 4-bit into one digit.

→ Hexadecimal or base-16 system uses sixteen digits to represent a number.

→ The first 10 digits 0-9 are same as decimal nos.

10	11	12	13	14	15
A	B	C	D	E	F

⇒ A hexadecimal number is indicated by a suffix h or a prefix 0x.

eg 0x10 ⇒ $(16)_{10}$

12h ⇒ $(18)_{10}$

$(\underline{0110}\ \underline{1001}\ \underline{0101}\ \underline{0011})_b$ ⇒ 6953h

6 9 5 3

⇓

$6\times16^3 + 9\times16^2 + 5\times16^1 + 3\times16^0$

⇓

$(26963)_{10}$

★ Negative number representation

↳ It can be represented by method called 2's Complement.

eg

1 ⇒ 0000 0001 ⇒ −1 = 1111 1110

{complimented}

⇒ For an n-bit field the range of the signed numbers that can be represented by that field is from -2^{n-1} to $2^{n-1}-1$

eg n = 8 ⇒ −128 to 127

Note: Representation of negative numbers in binary or hexadecimal formed is very dependent on the number of bits that are used to represent the number.

* Representation of Real Number

⇒ There are several methods available to represent real numbers; the most common is the IEEE-754 floating point method, which is used by all modern CPUs.

⇒ An IEEE-754 method: (using 32-bit field)

→ 0 to 22 bits are used to represent mantissa.

→ 23 to 30 used to represent exponent.

→ MSB or bit 31 is used to represent sign

(Sign × 2^{exponent} × mantissa)

(Both positive & negative)

→ 0 (Positive)
1 (Negative)

(Fraction)

(Value of exponent is computed from bit 23 to 30 by subtracting 127)

Eg

0 | 10000000 | 11110000000000000000000

Positive

128 − 127
=
1

$\left(1 + \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16}\right) = 1.9375$

$\Rightarrow + 2^1 \times 1.9375 = 3.875$

4.3) Microprocessors & Microcontrollers

Microprocessor

→ brain of modern Computer
eg ⇒ Core is
→ {Contains millions of transistor elements}

⇒ For personal Computer the microprocessor is housed on the motherboard of PC and uses an extend bus to interface with memory & other component.

{Set of Shared Communication lines}

⇒ The Combination of the microprocessor and the other elements on the motherboard is called a microcomputer.

Microcontroller

→ It is a Single-chip device that Contains a processor along with memory & Interface device on the same IC.

→ Microcontroller uses an Intrand bus to communicate with memory & other devices on the chip.

⇒ Microprocessor requires a peripherd chip to Interface with I/O devices.

⇒ Job of processor is to execute program instructions which are the low-level code.

↳ That is generated by the compiler in translating a high-level computer program into machine instructions, that is used by the particular processor.

⇒ Processor contains three basic units:

① Control unit

② Arithmetic & logic unit

③ Registers.

Control unit

→ Determines timing & sequence operation

→ It generates timing signals that are used to fetch a program instruction from memory & execute it.

Arithmetic & Logic unit

→ Performs logical evaluations and actual data manipulation (such as addition)

Registers

→ Memory locations inside CPU that holds intermediate data while instructions are being executed.

Different types of Memory

1. ROM (Read only memory)
   - Non volatile memory
   - Programmed with required content during manufacturing of IC.
   - It is used for fixed program such as Computer operating System.
2. PROM (Programmable ROM)
   - Same as ROM but can be programed once by the user with no further change allowed.
3. EPROM (Erasable PROM)
   - Can be programed more than once during use.
   - Content are erased by shining UV light through a quartz window on top of the device.
4. EEPROM (Electrically Erasable PROM)
   - Similar to EPROM, but content can be erased by applying a high-voltage signal rather than a UV light.
5. RAM (Random asses Memory)
   - Volatile memory that requires power to operate
   - Data is lost when power is removed.
   - The access time of the data is constant and is not dependent on the physical location of the data.

① SRAM (Static RAM)
→ Data does not need to be refreshed as long as power is applied
→ Data can be accessed faster than DRAM, but it is more expensive.

② DRAM → RAM that uses capacitors to store data.
→ Data must be refreshed (rewritten) periodically because of charge leaking..

Different type of Bus

→ Data bus
→ Used to transport data from/to the CPU & the memory or the I/O devices.
→ Data length could be 4, 8, 16, 32 or 64 bit.

→ Address bus
→ Used to select device on the bus or specific data locations within memory.
→ Each memory location has an address that must be specified before the content of that location can be accessed.

→ Control bus
→ Used to Synchronize the operation of the different elements.
→ It transmit read & write signal, System clock signals, and other control signal.

⇒ Microprocessors & microcontrollers are designed using two design approaches.

ⓐ → Complex instruction Set Computer (CISC)

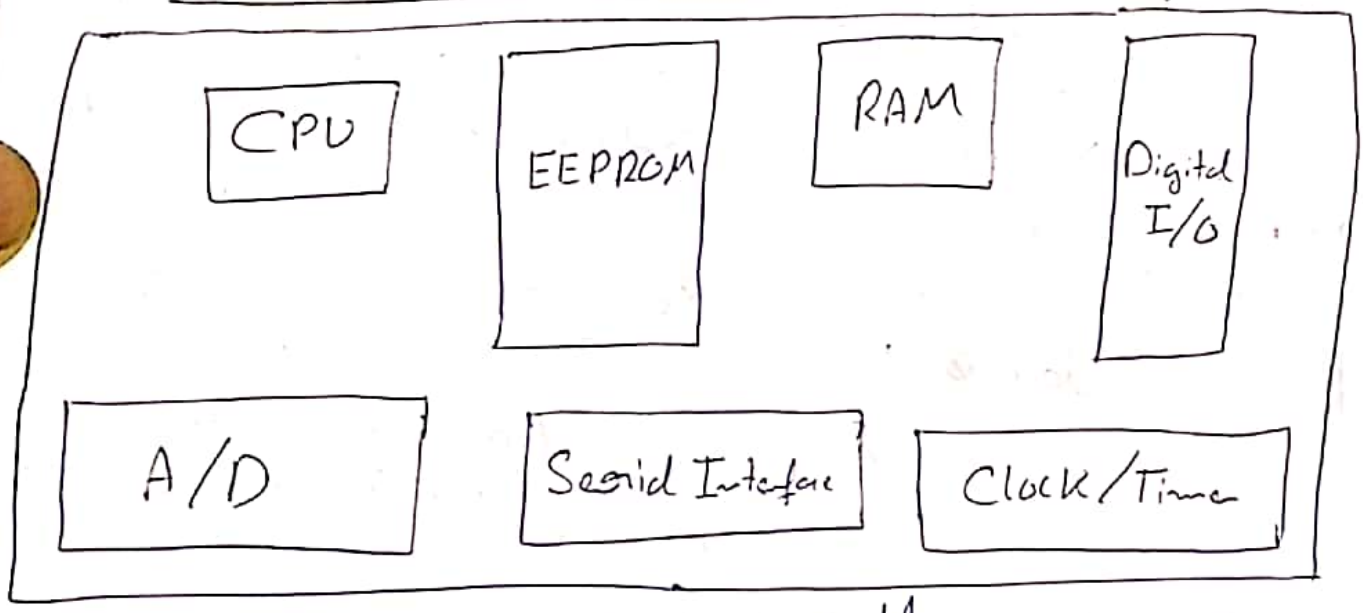
ⓑ → Reduced instruction Set Computer (RISC)

@ → CISC processor uses more complicated instructions that can perform more functions.

ⓑ → RISC processor uses small number of simple instruction optimized for fast execution.

⇒ Compiled program for a RISC processor tends to be larger than that for a CISC processor, but it can run fast.

4.4) PIC Microcontroller



Components of typical Microcontroller

EEPROM ⇒ Used to store code.

RAM ⇒ To store data while program is executing

★ PIC Microcontroller family

⇒ Many of the MCU's have program memory that is referred to as flash memory.

⇒ Flash memory can be erased & programmed electrically, similar to an EEPROM but without the need for a dedicated programmer.

↳ However, flash memory does not allow an individual memory location to be erased: only a single block of memory location can be erased.

⇒ Program memory & data memory have separate buses to allow concurrent access.

* PIN Layout

- PDIP — {Plastic dual inline package}
- SOIC — {Small-outline integrated circuit}
- SSOP — {Shrink small outline package}

Used in surface mount type circuit

* PIC MCU Components

① Clock / Oscillator Source

⇒ All CPU operations are synchronized with the clock.

↳ Any device that can produce a train of pulses at fixed frequency

⇒ Some chip have a built in clock source & some require or allow an external device to produce the clock pulses.

eg ⇒ quartz crystal resonator, ceramic resonator, RC circuit.

⊙ I/O and A/D Operation

⇒ Before a digital I/O pin is used, the pin should be configured to either input or output.

1 → digital input
0 → digital output

⇒ Each component on the MCU has a number of registers that control its operation.

⊙ PWM Output & Reset Operation

PWM → PWM signal is a square-wave signal of fixed amplitude & frequency, but the width of the on & off part of the signal (or duty cycle) can be varied.

4.5) Programming the PIC Microcontroller

⇒ In microcontroller, a program can be developed using a high-level programing language but also can be developed using (assembly language)

→ {Low level programming language that is specific to microcontroller used.}

(Assembly Code) ——Compiler——→ (Binary Code) → Hex Code file

⇒ The binary code (or hex code file) is then downloaded to the microcontroller to be stored in the non-volatile program memory.

* Programmers
  - The process of transferring a compiled binary code to the MCU is called programming.

ICSP ⇒ Integrated Circuit Serial programing
- Two pin { data pin, clock pin }
- An advantage of ICSP is that the chip does not have to be removed from the development or target hardware.

* Bootloaders
- Bootloader is code that resides on the MCU program memory.
  - ↳ normally used for main program.
- Bootloading code uses an RS232 serial line to communicate with a corresponding PC bootloading application.
- PC bootloading allows the user to download hex file to the PIC MCU without the use of any external programmer.
- Microchip Technologies provides the AN1310 Software package, which is a high-speed bootloader for PIC16 & PIC18 devices.

★ C Programming Language

⇒ There are several C-language compilers for PIC MCU.

eg ⇒ PCWH Compiler