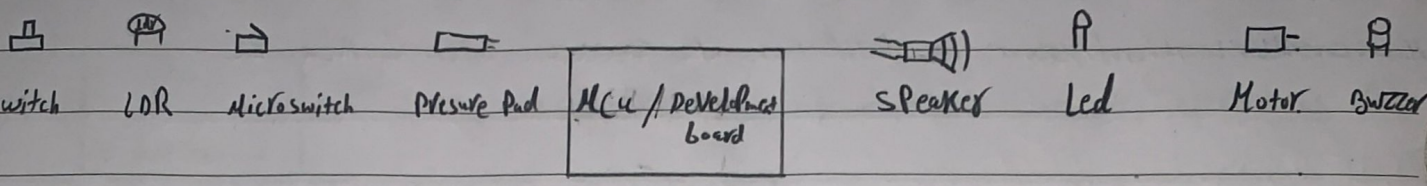
التاريخ: / / الموضوع: _____

old intro to micro controller interfacing:

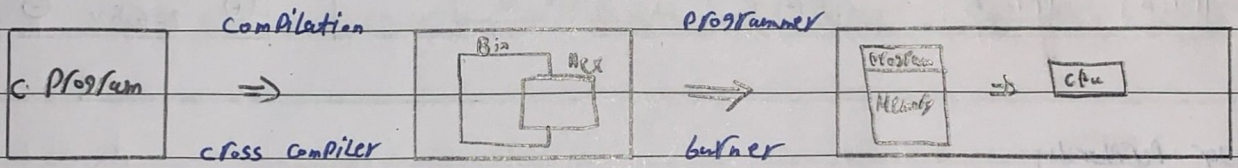


input process output

inputs: devices give a signal to micro controller.

process: taking input signals and make operations.

outputs: devices that Recive the input signal after Processing.

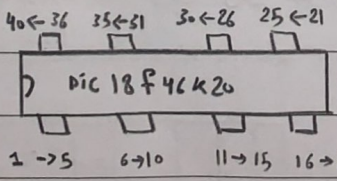


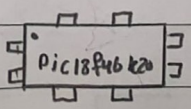
Host Machine executive code target machine

types of Compiler tool chain:

1. Native Compiler: single Device Compiler "Host, target" are same device.
2. cross Compiler: Multi Device Compiler.

shapes of microcontrollers:

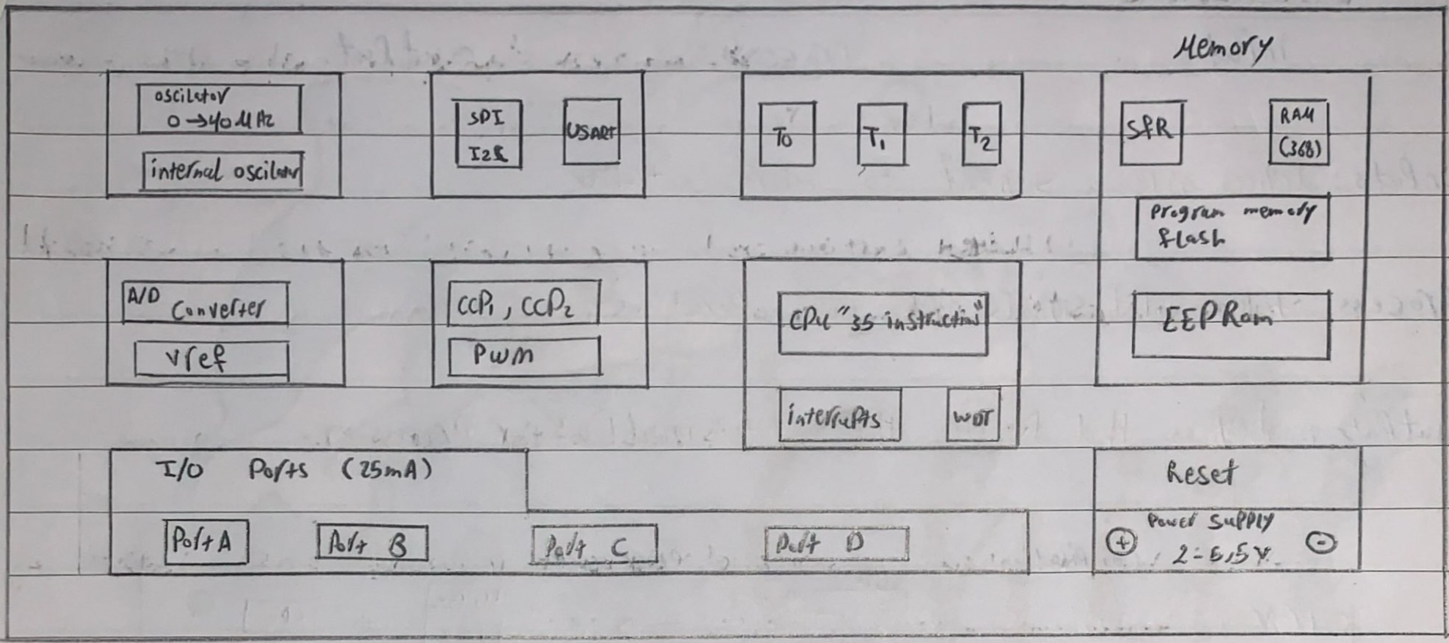




trough hole microcontroller service Mount microcontroller

MicroProcessor: chip that make all operations and connect with all devices by buses.

MicroController: MicroProcessor + Peripherals are conected internal MCU IC.

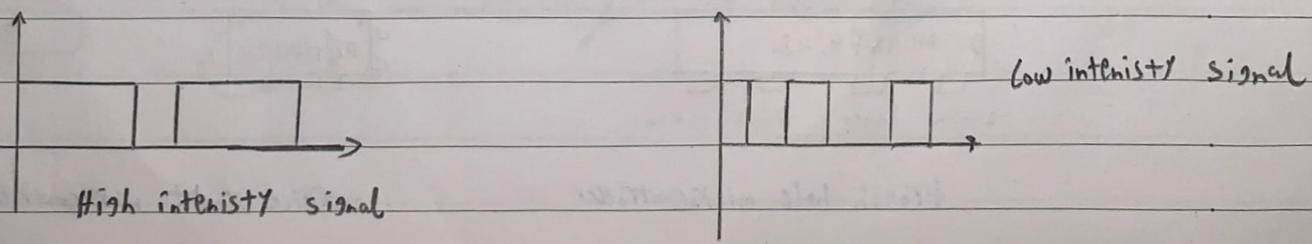


MicroController Peripherals:

1. RAM: "stack - heap - bss - data" بتخزن الداتا الناتجة سواء عليه أثناء الـ Runtime ويرحلها للـ EEPRom
2. Flash: "data - vector - I/O - code" موجود فيها الـ code اللي بينفذه الـ micro controller
3. EEPRom: موجود فيها الـ old inputs, data "في حالة انقطاع الكهرباء بيكمل شغال" inputs فيها

4. Ports: الوسيلة الوحيدة للتواصل مع الـ microcontroller سواء "input - output"

5. A/D Converter: Convert Analog signal to digital signal
6. PWM "Pulse width modulation": بيتحكم في شدة او قوة الـ signal عن طريق عرض الموجة



الموضوع: _____ التاريخ: / /

7. CPU: ال Central Process Unit المسؤول عن كل العمليات اللي بتتنفذ داخل ال micro controller

CPU
35 instructions

* ال instructions: هي عدد العمليات اللي يقدر ال Micro Processor ينفذها

8. Timers: "$T_0 \rightarrow T_3$" سئولة عن الوقت اللي بياخده اي عملية على حسب الكود

9. interrupts: سئولة عن انها تقطع اي عملية وتستخلص شغل ال "output Pins - Timer"

10. Serial Communications: ال micro controller بيعمل بيها تواصل سواء بين 2 micro controller او ال Iot Module
"SPI - I2C - UART/USART - CAN - Ethernet"

11. oscilator: سئولة عن ال clock Pulse او اخراج الموجات

12. Sfr "special function register": Configuration for all Peripherals بيتكون من ليها وظائف محددة وغالبا"

الموضوع: ______ التاريخ: / /

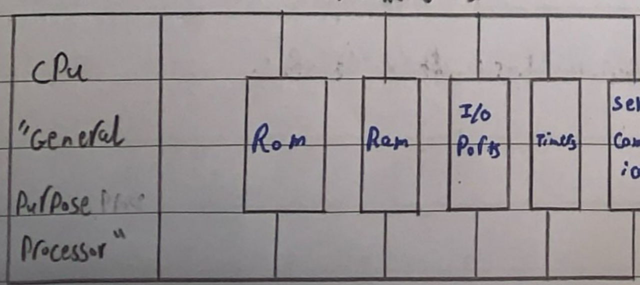
new intro to micro controller interfacing |

* زى ما عرفنا فى ال old intro ان ال C Program علشان يتحول لـ Machine code بيعدى على ال Compiler ال compiler ال بيكون عبارة عن مجموعة من ال tool chain واسمها عامة ال tool chain وال tool chain دى عبارة عن مجموعة من ال executable files بتأدى وظيفة معينة زى "as / ld / g++ / gcc" وكل tool بتسلم ال tool الى بعدها لحد ما ال C Program يتحول من HLL لـ Machine code.

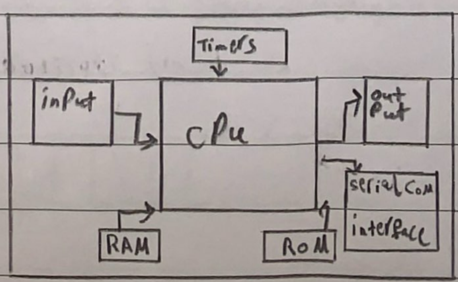
Embedded c: is a techniques of code writing that improve the efficient of code and try to take the least Memory of micro controller.

	Computer	micro controller	Computer & micro controller systems:
Ram	"64 - 32 - 16 - 8" Gigabyte	200Byte => 2KB/32KByte	1. CPU for Computers: - No internal Ram, Rom
Rom	terabyte	" upto 512 KByte	and I/O on CPU chip itself
Power Consumption	watt	millie watt	2. Micro controller: microprocessor + internal Peripherals
CPU speed	GHz	MHz	in "single chip"
CPU called	Processor "General Purpose Processor"	Micro Processor	

Motherboard



MCU
chip



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Characteristics of Embedded systems Applications:

- Single functioned" excutes a single program repeatly" => for only one device
- tightly constrained: "low cost, low power, small, fast"
- Reactive and Realtime: a. continually reacts to changes in the system's environment.
  b. Must compute certain results in realtime without delay.
- unit cost: the monetary cost of manufacturing each copy of the system, excluding NRE
- NRE cost "non-Recurring Engineering cost": the one time monetary cost of research, develop, design and test the system.
- size: the Physical space required by the system.
- Performance: the execution time or throughput of the system.
- Power: the amount of Power consumed by the system.
- Flexibility: the ability to change the functionality of the system without incurring heavy NRE cos
- Time to Prototype: the time needed to build working version of the system.
- Time to market: the time to develop a system to the point that it can be released and sold to customers.

Maintainability: the ability to modify the system after initial realse.

الموضوع: ____ التاريخ: / /

SoC "system on chip": integrates almost all of these components into a single chip.

- we can build a complete computer with just a single SoC

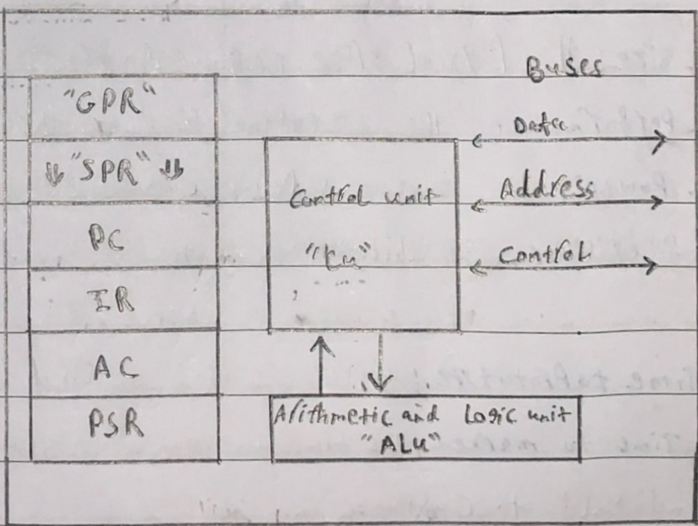
APPs: speech signal processing image and video signal processing

* Automotive industral
* functional safety
* communication baseband
* magnetic and solid state storage

CPU: "central processing unit" of any microcontroller, the main purpose of it is to excute our code.

- to perform these functions, the CPU contains components:

* ال cpu في micro controller بياخد ال machine code على اجزاء اسمها instructions كل instruction عبارة عن zeros & ones العملية دية اسمها fetch وبيقوم بيها ال control unit



the major component of CPU:

1. Control unit "CU"
2. Arithmetic and logic unit "ALU"
3. Register Bank " group of special function/gener purpose registers

1. Control unit "CU": Consists of 2 Major Parts

a- fetch circuit: fetch the instructions from the Program memory.

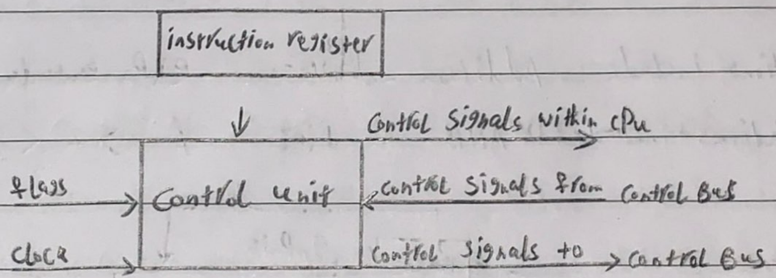
- each instruction is a Pattern of zero's & ones.

b- instruction Decoder circuit: it's used to Control the operation of the Processor.

- interprets or decode the instructions
- signal the ALU to respond to the instructions

* instructions sets: it's all instruction that CPU Can Perform.

instruction ⇐	=> op Code
Add	011
Sub	101
And	110
OR	001
XoR	111
Shift	100



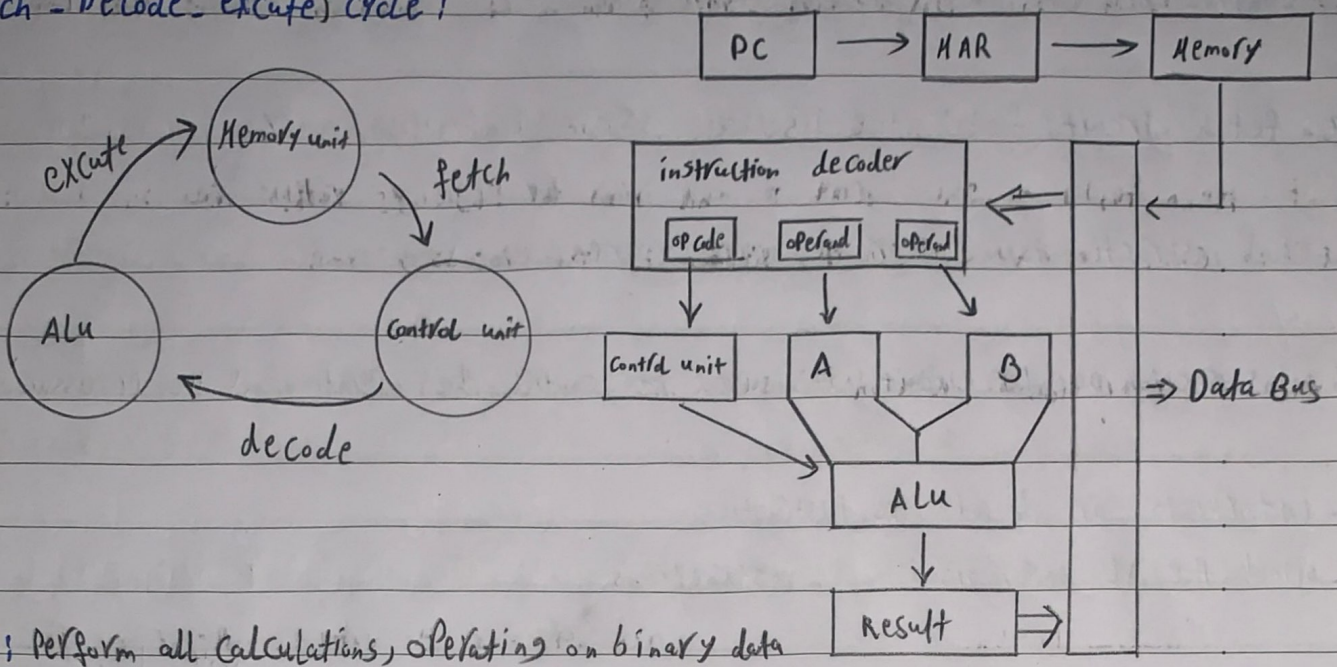
instruction: 0000 0101   0001 0 ... 1100

op Code: define the operation to the CPU to Carry out. → operands: Contain it's Parameters for the operation to excute on

* each instruction has op Code
* instruction decoder => decode instruction
* ALU => Perform instruction
* كل شركة بتعمل instruction set خاص بيها لكل ال instruction ال CPU بيقدر يعمله "+ , - , * , /"

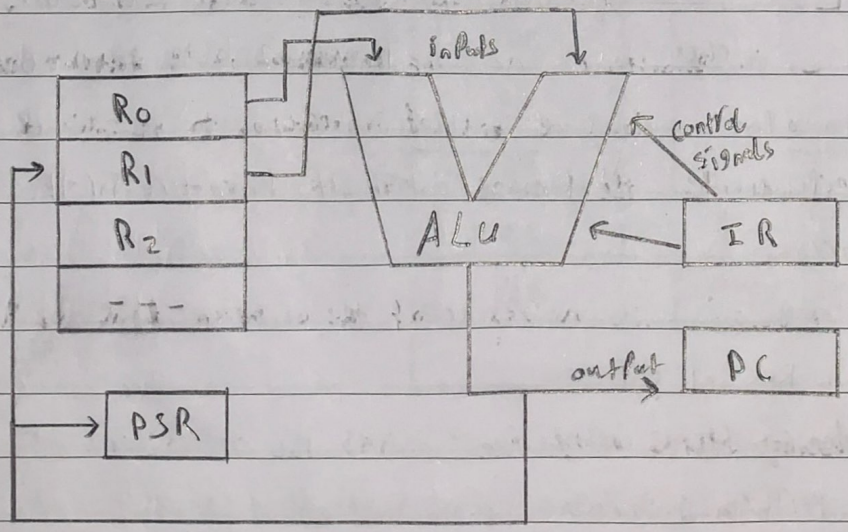
* number of instruction digits express the number of instructions that the CPU can perform by the relation => $[2^{n-1}+1 ; 2^n-1]$

(fetch - Decode - excute) cycle :



ALU : Perform all calculations, operating on binary data with arithmetic and logical functions.

* Arithmetic operations include : Addition - division - exponentials - logarithms.
* Logical operations include: "AND - OR - NOT" / ">" "<" "<=" ">=" "==" "!="



the signal from the control unit will activate special circuit in ALU to execute the needed operations.

التاريخ: / / الموضوع:

Registers: is a high speed memory storing units is a memory device that can store 8, 16, 32 bit values.

*it's much faster to shift data to and from the registers rather than in and out of the cache or RAM and so this speeds up the processing time.

*there are many registers available inside the CPU, some of which have a specific name and purpose

there are two types of registers in the Bank:

1. GPRs "General Purpose Registers": Normally used to hold the data to operate on it.

2. SPRs "special Purpose Registers": registers have a specific functions

a. PC "Program Counter": Hold the memory address of the instruction to be excuted

* الـ PC فيه عنوان الـ instruction الي عليه الدور للتنفيذ وليس الـ instruction الحالي.

*fetch circuit usually use PC register to know the instruction to be fetched each time

b. IR "instruction register": Hold the fetched instruction to be excuted

* instruction decoder decodes the fetched instruction stored in the IR.

c. AC "Accumulator register": Has the result of the operation done by the ALU.

d. PSW/PSR "Processor status word/register" Has the status of the last operation done by the ALU.

e. SP "stack Pointer register": Hold the address of a special chunk of main memory used for temporary storage during program excution

* غالباً SP يـ Point على الـ stack segment جوا الـ RAM.

الموضوع: ______ التاريخ: / /

LR "Link Register": this used for holding the return address when calling a function or subroutine.

* هو ده المسئول عن "Context switch" عنوان الحالة الى الـ CPU بيسيب فيها الـ main function علشان ينفذ sub function اخرى ولما يخلص يرجع الـ main function بنفس الحالة الى سابها.

* كل الـ "SPR" ملهمش Addresses فى الـ memory علشان كده مقدرش اعملهم access الا باستخدام Assembly instruction

* لما الـ instruction بينفذ بياخد الـ operands بتوعها فى الـ "GPR" بس ده ممكن ياخد وقت علشان كده فى الـ C ممكن استخدم الـ keyword "register" علشان اسرع "data calling" فى الـ Runtime

Bus: is an electric Path way between multiple devices

* Can be internal to the CPU, to transport data to and from ALU
* Can be external to the CPU, to connect it to memory or I/O Devices

* early PCs had a single external Bus or "system Bus"
* there are at least three types of Busses.

a- Address Bus: Send addresses from CPU to memory
b- Data Bus: Read and write data from memory
c- Control Bus: Read or write operation

* when you send more than 1 electrical signal on a Bus, it cause a short circuit.

التاريخ: / /

الموضوع:

Data Bus: the more wires you use, the more costly the computer system will be comes
: it's like the number of lanes

* the width of the data bus determines the amount of data transferred per memory transfer operation and determine the number of data can transfer per time unit.
* in one time unit processor can only read or write

* a data bus that consists 8 bits can transfer 1 Byte of Data per reading of writing operation
* a data bus that consists 16 bits can transfer 2 Bytes of Data per reading or writing operation
* a data bus that consists 32 bits can transfer 4 Bytes of Data per reading or writing operation

Address Bus: used to send address (location) information to memory.

* the data bus doesn't have to be the same width as data Bus.
* the width of the add Bus determine the size of the memory that the Compute can use.
* the wider address bus, the more memory a Computer can use
* More memory allows the Computer to store more data and solve larger size problems

* an address Bus that consists 8 bits, can convey 2^{8} different addresses "0 → 255"
* an address Bus that consists 16 bits, can convey 2^{16} different addresses "0 → $2^{16}-1$"
* an address Bus that consists 24 bits, can convey 2^{24} different addresses "0 → $2^{24}-1$"
* an address Bus that consists 32 bits, can convey 2^{32} different addresses "0 → $2^{32}-1$"

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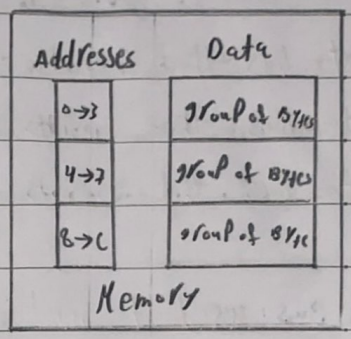
Memory organization:

* the Bit is the building block of memory and stores 1 Piece of Boolean information (0,1)
* Byte is a group of Bit, and can store a Binary values with a Length of 8 Bits
* Double Byte are group of Bytes, and can store a Binary values with a Length of 16 Bits
* Quad Byte are group of double Bytes, and can store a Binary values with a Length of 32 Bits

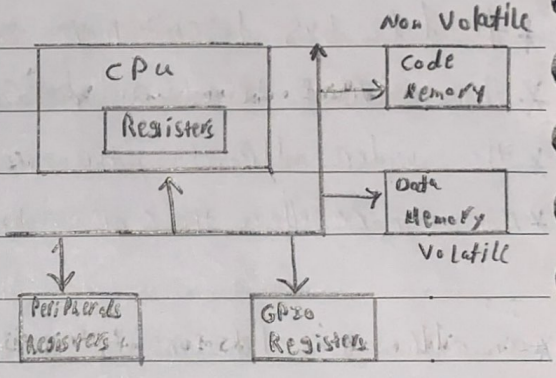
Memory scale example:

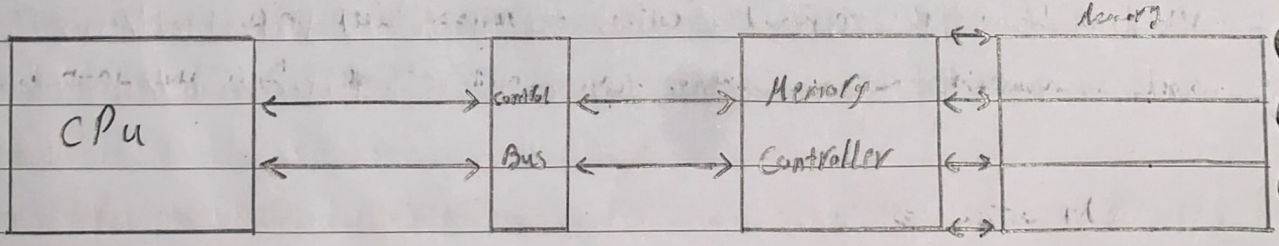
1. Data Center: Peta Bytes
2. Personal Computer: Mega Bytes → Tera Bytes
3. Embedded system Applications: Kilo Byte → Mega Byte



types of memory:

1. Code memory "Non Volatile": Flash memory
2. Data memory "Volatile": SRAM
3. Run time state Registers "Volatile": GPR - SPR



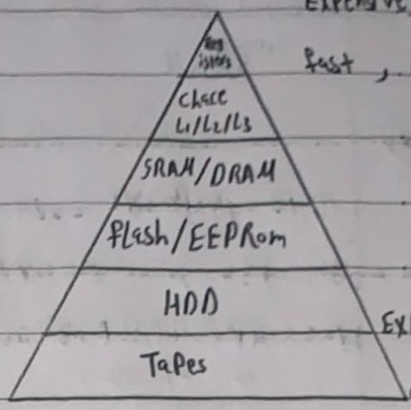


* ال Memory Controller وال Controller Bus بيتحكموا في العمليات اللي بتحصل في ال Memory وهما "read - write - strobe - enable - data - add"

التاريخ: / / الموضوع: _____

Memory characteristics:

* Capacity
* Volatility
* Access "way to access"
* Power Consumption
* Latency "time to read and write data"
* Durability "Number of times for read or write from memory"
* transaction size "the capacity of Data that I read or write"



Types of memory:

Volatile Memory: very fast, but Cannot hold data without Power.

1. SRAM "static Random access memory"
2. DRAM "Dynamic Random access memory"; it's name Comes from the fact the data stored in this Ram needs to be refreshed every few milliseconds or else it will end up being erased.

* DRAM use the capacitors instead of transistors "SRAM".
* Capacitor يفقد الشحنة Per time Voltage Lost
* DRAM Controller is the responsable circuit to refresh data in DRAM.
* Embedded microcontroller these days usually have a mix of both SRAMs and DRams.

SRAM X4 speed => DRAM

SRAM > DRAM "Number of transistors per bit of data, more expensive Compared to DRam

	SRAM	DRAM
Cost	more expensive	Low expensive
Construction Principle	cross coupled flip flop cotinsion of transistors	Capacitor circuit
Speed	X4 speed more	X4 speed Less
Volatility	as Long as Power on	data needs to Continously refreshed
Power Consumption	Less	more

Non Volatile Memory: dosen't care if the Power is Present or not they are relatively slow.

Masked Rom: it's imposible to change them.

RRom "Programmable Read only memory": the main characteristics being it can only be Programmed one time.

*OTP: one time programmable devices.

EPRom "Erasable Programmable Rom": We Can Programe it more than one time, but it's very Complex.

EEPRom "Electrical Erasable PRom": this chip can be erased and reprogrammed using electricity

* تقدر تعدل read/write في نفس الوقت

الموضوع: _____ التاريخ: / /

3 different functionality EEPRom:

1. Storing firmwire during the development Phase of the Product.
2. Storing runtime Constants after production.
3. Storing updatable firmwire after Production.

EEPROM
Mainly in KBytes in 8 bit MCU : 1K, 2K, 4K max
Mainly in KBytes in 16 bit MCU : 8K, 16K max
Mainly in KBytes in 32 bit MCU : 32K max

flash: Most Popular in Embedded development
Some of flash can't read and write at the same time Like EEPRom.

NVRAM: "non volatile Random access memory" : Can store data Permanently [SRAM + Power supply]

flash memory technologie ⇒ NAND flash memory.
EEPRom technologie ⇒ NoR flash memory.