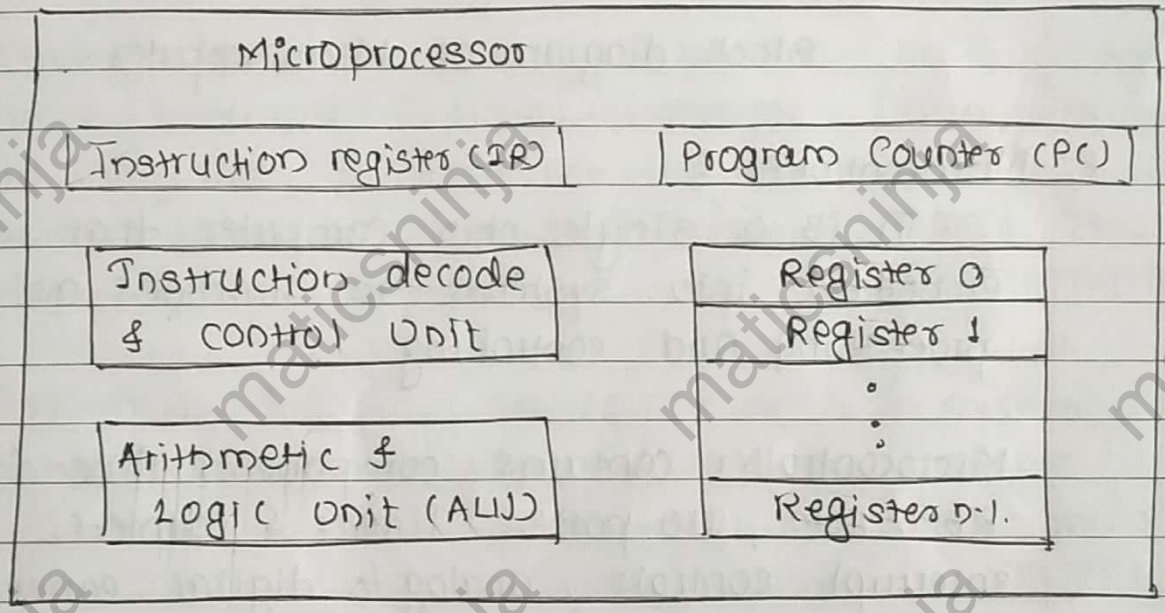
Unit - III

Marks 16

Basics of Microprocessor & 8051 Microcontroller

* Microprocessor :

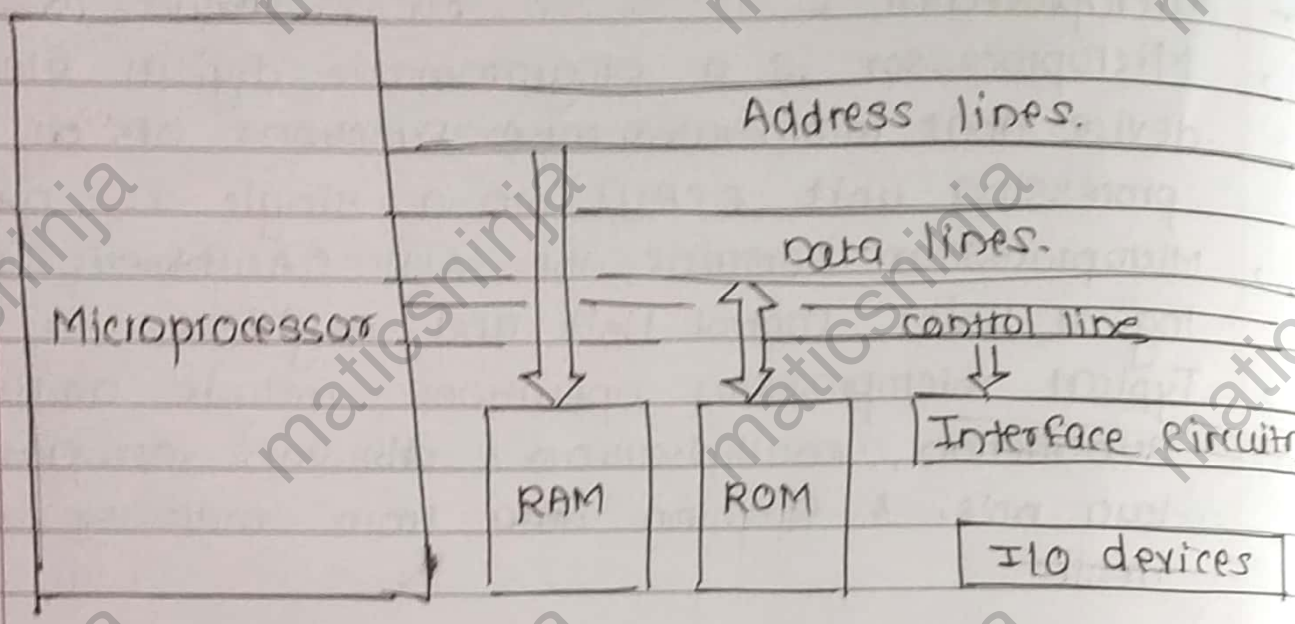
- Microprocessor is a programmable digital electronic device that incorporates the functions of a central processing unit (CPU) into a single IC package.
- Microprocessor contains the ALU (Arithmetic & logical Units), Control Unit and Registers.
- Typical microprocessor operations include addition, subtraction, multiplication, division, comparing two no's. & fetching data from memory or I/O device.



* Microcomputer :

- A complete computer built on a single circuit board, with microprocessor, memory, input/output ports & other features required as a functional computer which is called as single-board microcomputer.

If a memory, input/output (I/O) devices & a clock circuit are added to a microprocessor then it is called as a microcomputer.



Block diagram of Microcomputer.

* Microcontroller:

It is a single chip computer that is embedded into systems to functions as processing and controlling

Microcontroller contains components like CPU, RAM, ROM, I1O ports, Timers & counters, interrupt controls., analog to digital converters, digital to analog converters, serial interfacing ports, oscillatory circuits.

Comparision of microprocessor, microcontroller, microcomputer

Microcontroller	Microprocessor	Microcomputer
1) Inbuilt RAM or ROM.	Do not have built RAM or ROM.	Inbuilt RAM or ROM.
2) Separate memory to store program & data.	Program & data are stored in same memory	Separate memory to store program & data.
3) Memory, I/O ports, timers, interrupts are integrated inside the uc chip.	Memory, I/O ports, timers, interrupts are not integrated inside the chip.	uc is a single chip microcomputer with on-board ROM & I/O that can be programm-ed.
4) System is simple economic & compact.	System is bulky & expensive as it requires additional components.	System is simple, economic & compact.
5) Low accessing time	Higher accessing time.	Low accessing time
6) Few instructions are required for operation.	Many instructions are required.	Few instructions are required.
7) e.g. Intel 8051, PIC16F877.	e.g. Intel 8086, Intel pentium series	e.g. video game, mobile phone, Laptop. etc

* Types of Buses :

There are three types of buses -

1) Address Bus
2) Data Bus
3) Control Bus.

1) Address Bus :

These are unidirectional buses used to tran address signals generated by microprocessor.

2) Data Bus :

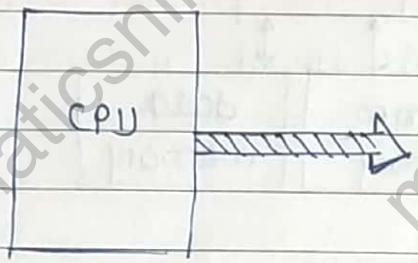
These are bidirectional buses used to tran data from microprocessor to memory or I/O a from I/O to microprocessor. It perform's read as well as write operation.

3) Control Bus :

These are unidirectional buses used t transmit control signals such as read, write and interrupt control signal.

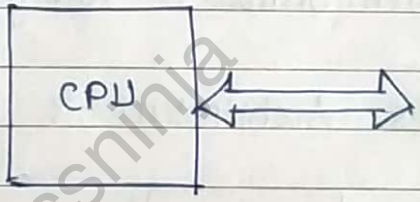
* Address bus :-

It is a unidirectional bus. The address assigned to a given device must be unique. No two devices are allowed to have same address.



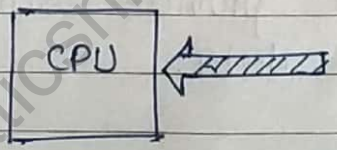
* Data bus :

It is a bidirectional or unidirectional bus. The CPU uses the data bus either to get data from that device or to send data to it.



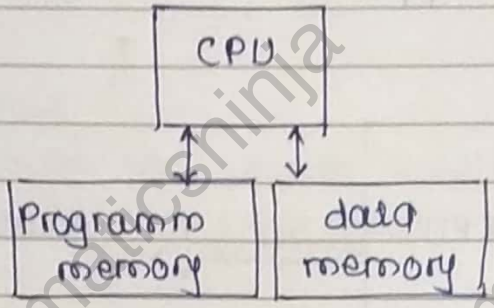
* Control bus :

Control bus is used to provide read or write signals to the device, to indicate that CPU is asking for information sending it or not. e.g. $\overline{MEMR}$ / $\overline{MEMW}$, IOR, $\overline{IOW}$ operations



Types of Architecture :

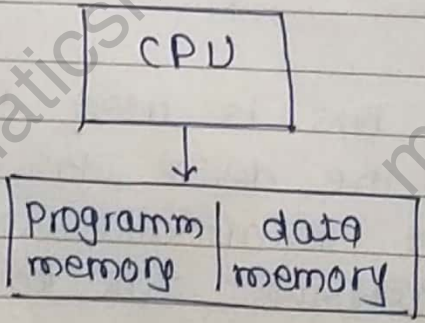
1) Harduard architecture :



- fig shows architecture of harduard, this architecture uses separate memory for programme and data.
- It contains independent address and data bus. There is no need to have time division multiplexing of address and data bus.
- It allows different internal organization such that instruction can be prefetched and decoded simultaneously. It requires only one clock cycle.

eg. -8051 microcontroller family.

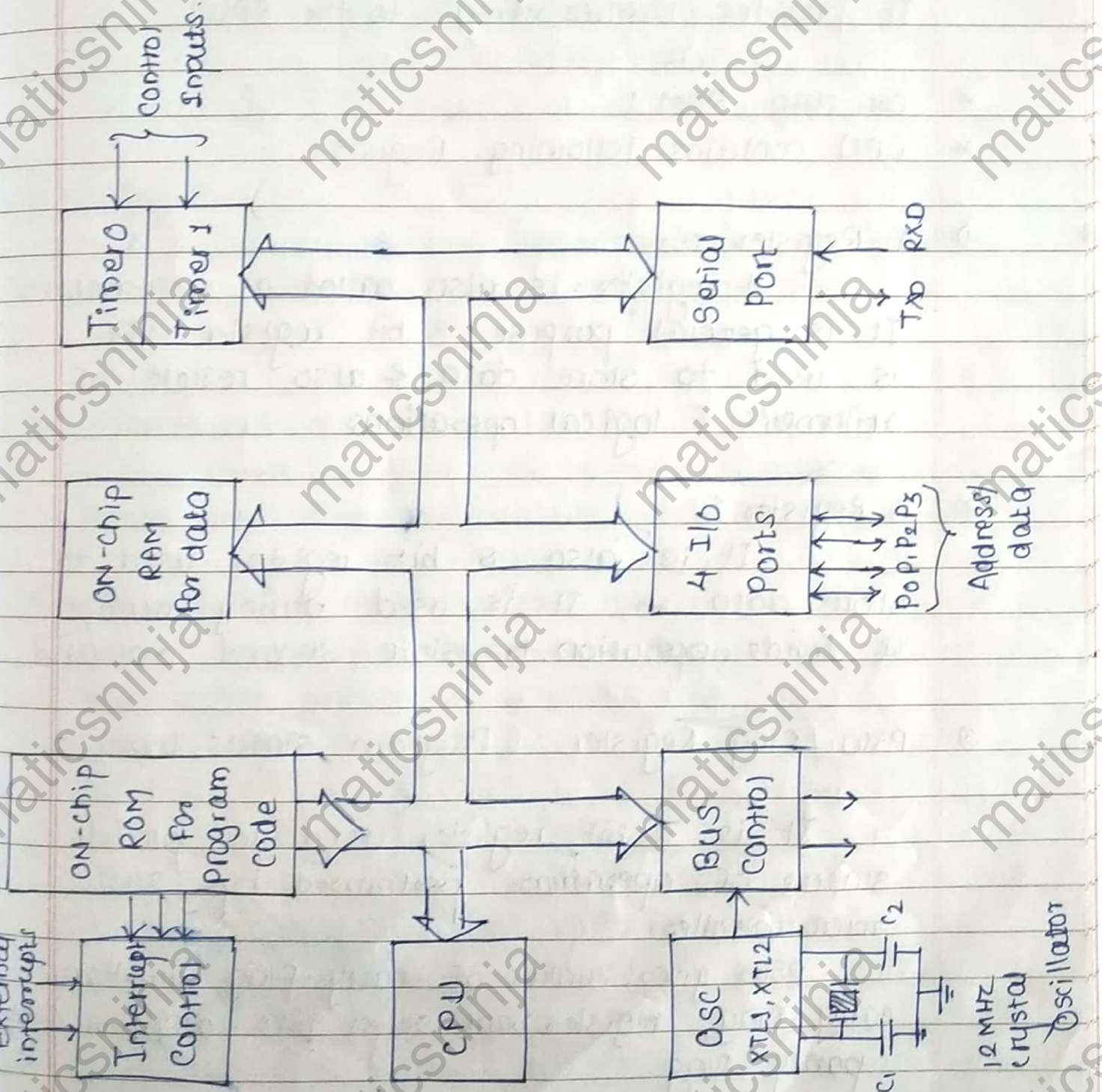
2) Von Neumann's Architecture :



- This architecture provide same memory for programm and data.

- It requires two clock cycles to complete its operation. In first clock cycle the instruction is fetched & in second clock cycle data is fetched.
- Programm and data are fetched sequentially.
- Its design is simple.

8051 Microcontroller Architecture :



* CPU : It is the main control system in uc which performs all functions i.e arithmetic as well as logic operations.

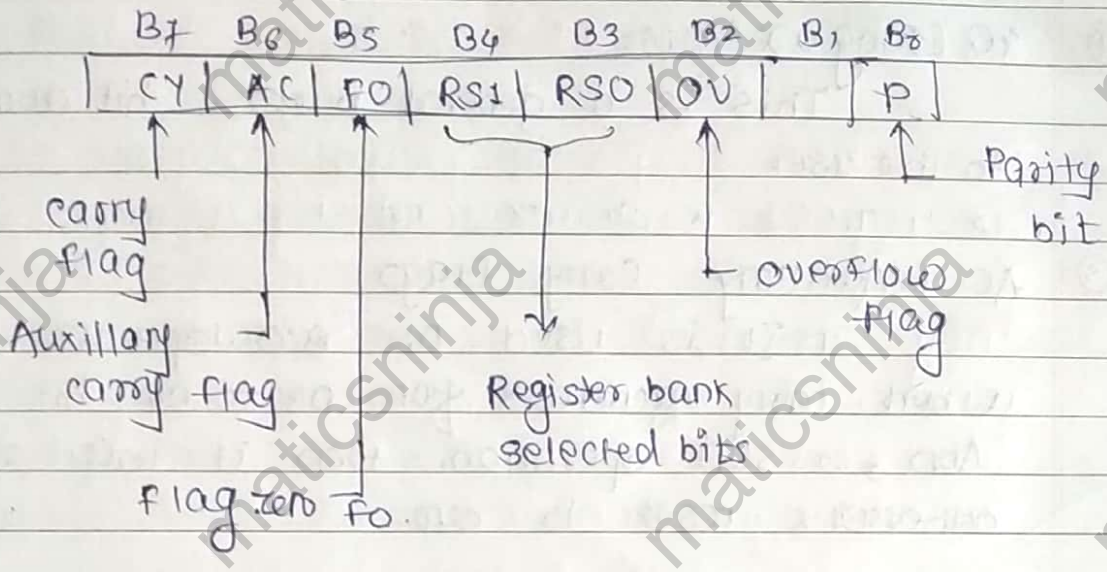
* Oscillator : The quartz crystal oscillator is used in this control system.
It has two pins XTAL1 and XTAL2
It provides 12 MHz freqn to the CPU.

* ~~On chip RAM~~ :
* CPU contains following Registers :-

1) A Register :
A register is also called as accumulator It is general purpose 8 bit register. It is used to store data & also result of arithmetic & logical operations.

2) B Register :
It is also 8 bit register used to store data ~~in~~. It is used during multiply & divide operation to store second operand.

3) PSW / Flag Register (Program status word) :
It is 8 bit register used to provide status of operation performed by 8051 microcontroller.
PSW gives status of carry flag, auxillary carry flag, register bank select bits, overflow flag, parity flag.



① Parity bit:

If the no of binary 1's in accumulator is even then this bit is set to 1 otherwise reset to 0.

② Overflow flag:

Overflow flag set to the 1 when result has more size than register. otherwise reset to 0

③ RS0, RS1 (Register bank select bits):

These two bits are used to select one of four register banks in internal RAM

RS1	RS0	space in RAM
0	0	Bank0
0	1	Bank1
1	0	Bank2
1	1	Bank3.

④ F0 (Flag 0):

This is a general purpose bit available to the user.

⑤ AC (Auxillary Carry Flag):

It is used for BCD operation. When carry generates from D3 to D4 bit during ADD & SUB operation, then it will set to 1 otherwise reset to zero.

⑥ CY (carry flag):

When carry generates from D7 bit of 8 bit data then it is will set to 1 otherwise reset to 0.

Carry generates after ADD & SUB operation. This flag can be set & reset by using SETB, SETC

④ DPTR Register (Data Pointer DPL/DPH).

- It is special function register, combination of DPL & DPH which is 16 bit size
- It is used to point external RAM locations & instruction in code memory.
- It consist of two separate registers: DPH (data pointer high) & DPL (data pointer low) 8 bit separate register.
- Its range is from 0000H to FFFFH.

⑤ SP Register (Stack Pointer):

- It is used to point top of stack, stack is group of memory locations used for temporary range.
- PUSH & POP instructions are used access stack memory. During this operation SP will point stack memory.
- During PUSH, SP will increment by 1
- During POP, SP will decrement by 1

⑥ Program Counter (PC):

- It is 16 bit program counter register.
- It helps to start program execution.
- It indicates the address in memory from which next instruction is to be fetched.
- This instruction, If program counter value could be changed at any moment which will cause jump to a new location in the program memory
- It is used access subroutine or subprogram.

⑦ ALU:

It is arithmetic & logical unit. It is used to perform all arithmetic & logical operation. such as addition, subtraction, multiplication, division & ANDing, ORing, XORing etc.

It can be operate on 8 bit as well as 16 bit data.

⑤ R0 to R7 Registers:

> These are 8 general purpose register (R0 to R7) of register bank selected by using PSW register.
> They are used to store variables or intermediate result of operation.
> Two bits in PSW RS0 & RS1 will decide the active register bank.
> 8051 have four Register banks containing R0 to R7 registers.

R0	R1	R2	R3	R4	R5	R6	R7	Bank 0
R0	R1	R2	R3	R4	R5	R6	R7	Bank 1
R0	R1	R2	R3	R4	R5	R6	R7	Bank 2
R0	R1	R2	R3	R4	R5	R6	R7	Bank 3

They are used to store temporary data.

⑥ Input/output ports (I/O ports)

8051 has four I/O ports, each consisting of 8 bits. It can be used as input or output. If this pin is used as output then it should be applied to logic 0 & logic 1 as a input.

* SFRs (Special function Registers)

SFR is can be accessed as a normal internal RAM location. SFRs are B, A, PSW, IP, P3, IE, P2, SCON, P1, TCON, P0.

* Counters & Timers Registers:

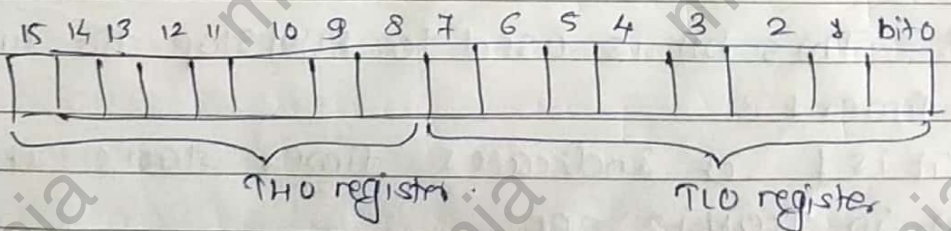
The 8051 has two timers Timer 0 & Timer 1. Each of these timer has a 16 bit register.

Functions of 8051 timers:

① Calculating the amount of time between two events
② Calculating the no. of events ie as counter.
③ Setting a baud rates.

1) Timer T0:

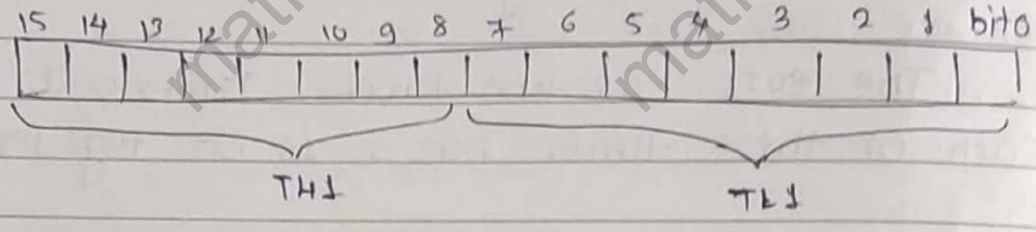
The 8051 contains 16 bit timer T0 register. lower 8 bits TL0 & 8 bits are called as TL0. & Higher 8 bits are called as TH0 register. If we use Timer 0 then it means TL0, TH0.



② Timer 1 (TH1 | TL1 timer):

It is 16 bit register.

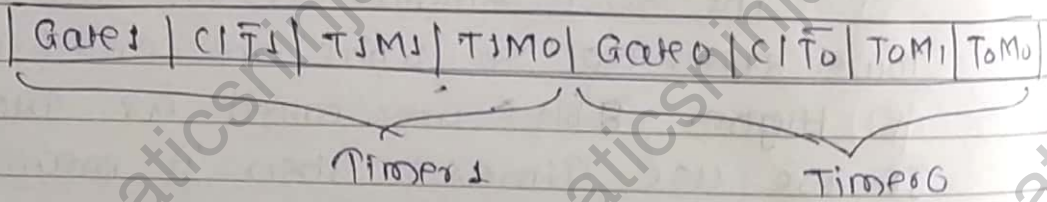
It is divided into two 8 bit's registers. Lower 8 bit's is called as TL1 & higher 8 bit's are called as TH1.



TMOD & TCON register is used ~~as~~ to control two timer 1 and timer 0.

* TMOD Register (Timer Mode):

TMOD Register is used to configure or change the operating mode of two timer's



Gate: This bit is used to RUN/Stop the timer 0 or timer 1.

If it is 1 it indicates timer starts if TR0 bit in TCON is set.

If it is 0 it indicates timer enable ~~it~~ to run if TR0 is set without using $\overline{INT}$.

C/$\overline{T}$: It is used to select timer as counter or timer.
1 → indicates acts as a counter by counting pulses.
0 → indicates act as a timer by counting internal oscillator frequency

> T_{OM_0} / T_{OM_1} or T_{iM_0} / T_{iM_1} →
These bits are used to select Timer 0 or Timer 1 operating mode.

T_{OM_1}	T_{OM_0}	Mode	Description
0	0	0	13 bit timer
0	1	1	16 bit timer
1	0	2	8 bit auto reload
1	1	3	Split mode

*> TCON Register:
Timer control Register is 8 bit register it is used to control two timers.

TCON	TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0

* TF1 (Timer1 overflow) / TF0 (timer 0 overflow):
These bit's are used to indicate the overflow of timer. If time counter exceeds it's counter.

> TR1 (timer 1 Run) / TR0 (Timer 0 Run):
It is used to ~~inter~~ indicate the timer is ON or Off.

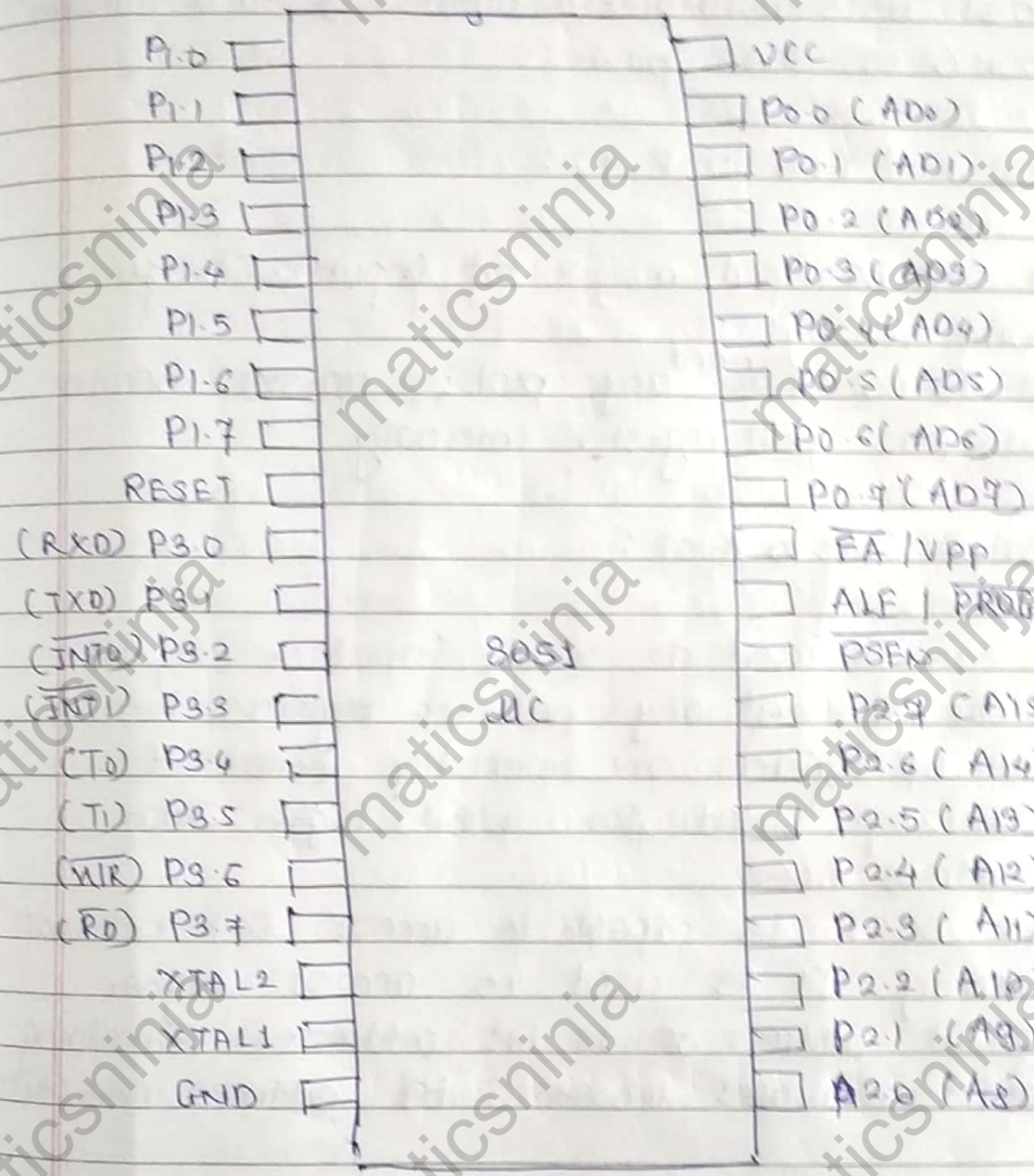
If it is 1 then it indicate timer 1/0 is ON
If it is 0 then it indicate timer 1/0 is off

7. IE0 / IE1 (External interrupt flag):
It indicate whether external interrupt is activate or not

8. IT0 / IT1 (Interrupt internal flag).
It indicates whether internal interrupt is activated or not

* Serial Communication Registers:
8051 use RXD & TXD pins to receive and transmit data serially. For this SBUF, SCON, PCON Registers are used. SBUF means serial buffer register, SCON means serial control register & PCON means power control register.

Pin diagram of 8051



1) Port 0 (AD0 to AD7):

- It is 8 bit port used as input as well output.
- It is also used to transmit address as well data for external memory.

> Port 0 uses AD_0 to AD_7 lines allowed to transfer address and data to external memory
> 8051 uses multiplexed address & data through port 0 to save pins.

II) Port 1 ($P_{1.0}$ to $P_{1.7}$):

> It can be used as 8 bit input or output port.
> It do not ~~have~~ need any pull up register because it has pull registers internally

III) Port 2 (A_8 to A_{15}):

> It can be used as 8 bit input or output.
> It do not need any pull up registers because pull up registers are internally connected.
> Port 2 is used for 8 bit higher order address lines.
> As 8051 is capable to access 64k external memory. It is used to access higher 8 bit address of 16 bit addresses. Remaining 8 bit indicates lower 8 bit address lines (A_0 to A_7)

IV) Port 3 ($P_{3.0}$ to $P_{3.7}$):

> Port 3 can be used as input or output
> Port 3 does not require any pull up resistors connected to it
> Port 3 has the alternate functions such as interrupt serial I/O, timer / counter, & read/write control for external memory.

Pin	Name	Alternate function
P3.0	RXD	Serial input pin
P3.1	TXD	Serial Output pin
P3.2	$\overline{INT0}$	External interrupt 0 i/p pin
P3.3	$\overline{INT1}$	External interrupt 1 i/p pin
P3.4	T0	Timer 0 external i/p pin
P3.5	T1	Timer 1 external i/p pin
P3.6	$\overline{WR}$	External data memory write signal
P3.7	$\overline{RD}$	External data memory read signal

* Reset:
It is used to reset the 8051 microcontroller. It is active high signal. After applying this signal 8051 microcontroller will reset the contents of register.

* ALE/ $\overline{PROG}$ (EPROM only):

It is an active high signal used to demultiplex the address and data bus by connecting the Latch 74LS373 IC.

› same pin ie PROG is used during EPROM programming

* $\overline{PSEN}$ (program store enable):

It is an output pin used to fetch the code from internal program memory.

* $\overline{EA}$ / VPP (External Access enable):

EA signal is active low used to fetch code from external program memory

VPP pin receive the 12.75V power which is called programming supply voltage while programming the PROM.

* XTAL1

This is an input to inverting oscillator amplifier & input to the internal clock generating circuits

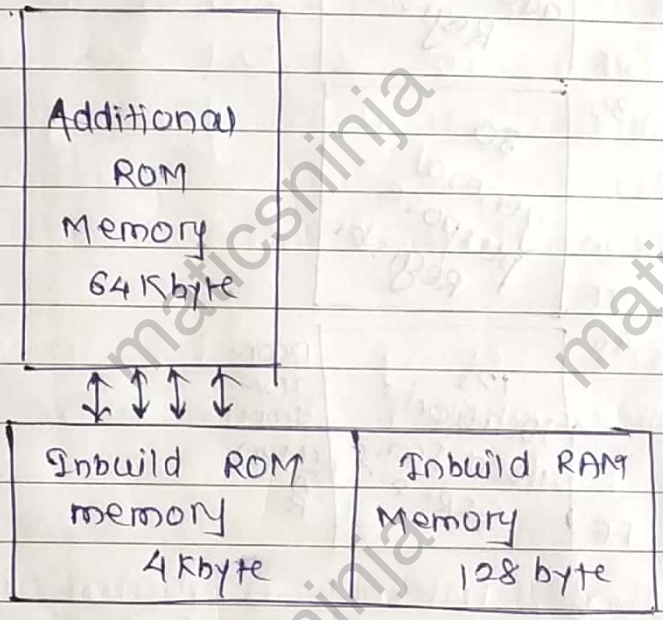
XTAL2:

This is an output line of the internal inverting oscillator amplifier.

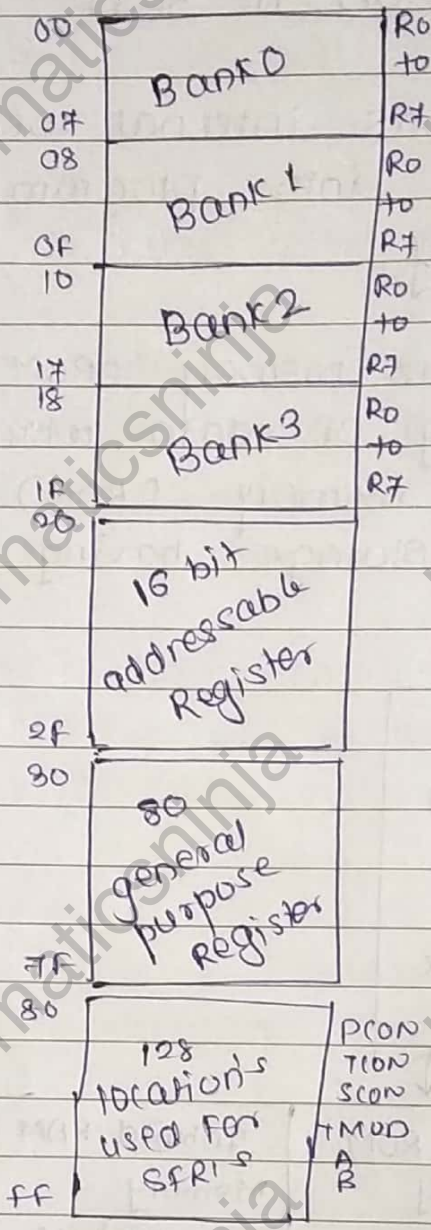
Memory Organization in 8051

The 8051 has internal memory which is divided into program memory and data memory.

It has program memory (ROM) is used for permanent storing of data which is 4 Kbyte.
It has data memory (RAM) is used for temporary data storage having size 128 byte.



8051 has internal ROM memory of size 4 KB.
It is used to store program only, not data.
The address of memory location is 16 bit.
EA (External Access) is used to select external ROM memory.
The external ROM can be expandable upto 64 KB.



* Data memory Organization.

The 128 byte of RAM is divided into several blocks. First four blocks is are used for 4 banks each contain 8 Registers R0 to R7. Next 20H to 2FH is used as 16 bit addressable register having address from 00H to 7FH. Next 30 to 7F is used to 80 general purpose register.

Remaining up to FFH is used for SFRs.

* 8051 Boolean Processor :

The 8051 microcontroller support bit addressable memory & bit manipulation instructions for boolean operation so, it is called as boolean processor.

Bit manipulation instructions mean's instruction which operate bit by bit.

e.g.

```
ORL  P0, #1
XRL  P0, #1
ANL  C, P1.4
CPL  P1.2
```

* Power Saving Options :

Power saving options is used to save energy during idle and power down time mode of microcontroller.

8051 Requires 25 mA current during it's normal operation.

In power saving mode it reduces it's power consumption to 40 uA.

It supports two power saving modes.

① Idle.
② Power down.

1) Idle Mode:

To ON µc in idle mode IDL bit in PCON register is used. If IDL=1 then it µc will be in idle mode or not.

In this mode I/O port's, timers, interrupts will continue operating normally consuming 6.5 mA.

All register's remains unchanged during this mode.

In this mode microcontroller in idle state If IDL bit is not set to 1 the µc will ~~RES~~ continues execution from previous state.

2) Power down Mode:

After setting PD bit in PCON register then microcontroller turns into idle power saving mode.

In this mode, internal oscillator will turn off to reduce power consumption.

In this mode µc will operate on 2V and require power upto 40 µA current.

In this content of all SFR register & I/O ports & internal RAM remains constant.

Hardware reset is required to terminate power down mode.

Comparision between 8031, 8051 & 8751.

Sl. No.	Specification	8031	8051	8751
1	Internal program memory	NO	4K ROM	4K UV EPROM
2.	Data memory RAM	128 byte	128 byte	128 byte
3.	Timer/counter	2×16 bit	2×16 bit	2×16 bit
4	Interrupt	5 with 2 level	5 with 2 level	5 with 2 level.
5.	I/O port 4×8 bit	Yes	Yes	Yes
6.	Data Pointer	No.	One	One
7	Power Consumption	High	High	Medium