classmate
Date
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-07-'19 # UNIT-I: EMBEDDED COMPUTING

- Introduction
- Complex Systems and Microprocessors
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Characteristics we need to tackle care of deadlines, improve performance
- → Complex Algorithms
- → Uses Interfaces (GPS), Complex Interface
- → Real Time (deadline)
- → Multivariate
- → Manufacturing Cost
- → Power and Energy

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Challenges
- → How much h/w do we need?
- → How do we meet deadlines?
- → How do we minimize power consumption?
- → How do we design for upgradability?
- → Complex Testing?
- → Limited observability and controlability?
- → Restricted development environment?

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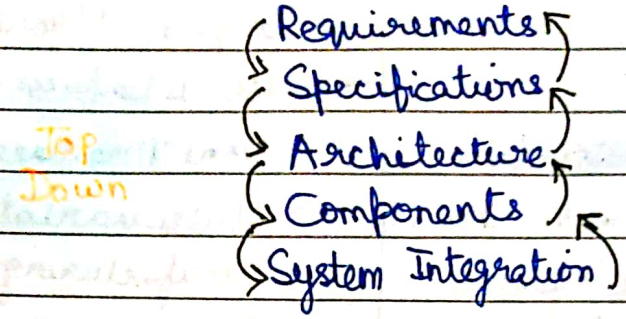
Performance
- → CPU
- → Platform
- → Program
- → Task
- → Multiprocessor

- The Embedded System Design Process

Normal Purpose - General Purpose

Embedded → which includes a microprocessor but not used for general purpose, i.e., specific purpose.

ES Design Process



- We will do all the programs using microcontrollers.
- A microcontroller is application specific: General Purpose, Only for one purpose, Only one operation
- A microprocessor is general purpose whereas a microcontroller is in built, one system contains all componenets.
- First Microprocessor - Intel 4004
  Calculator Operation - Calculator Application
- In a microprocessor, all connections are external.
- When we are upgrading something, we need to think about cost vs performance.
- We need to generate embedded system in such a way that programming should take less power and energy.
- Why do we use microprocessor for Embedded System?
  This is because any app can be run or implemented on microprocessor.
- Here: Components = Component Design

Challenges:

i) ES comes with hardware
- Optimize the hardware, in case also, we use ES (embedded system), many vehicles, application specific.

ii) Real Time
- Cost vs Performance

iii) Eg: Battery in Mobile Phones
Before it was very large, now it is small and large utilization

★ iv) ES installed software - we are using it with little changes. We need to make upgradability. It should execute a new program when it is upgraded.

v) vi) vii) } Same Concept — Write program on common desktop, compile and execute

How to improve performance of ES?
- It depends on processor (CPU)
- Depends on wires, buses, (platform), connection media
- Layer program into smaller one (program)
- Multitasking (single processor doing many tasks)
- Multiprocessor (it contains many processors)

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In ES, Hexcode is not written manually.
- We will be writing C and C++ programs
- Hexfile will go to ES. Before dumping, we need to check all the possibilities when doing in ES (it is also one of the challenges).
- Testing on desktop.
- We cannot change it in ES, so before dumping, we ~~only~~ need to check. It is one of the disadvantages.
- In ES, we can read hardly 30 characters, but in other processors, it can read all characters, i.e., 1550.

ES Design Process (5 mks, explain with applica

i) It is a 5 step process
It basically uses top-down approach.
I/P, O/P
Cost
Performance of System
ii) Specifications
iii) Architecture - what it does
Organization - How it does
(i/P, O/P, how many different hardware, how many sensors)
iv) Each and every component
(which component for what purpose)
v) Combining is System Integration

EA
ALE
PSEN
XTAL1
XTAL2
RESET
Vcc
GND

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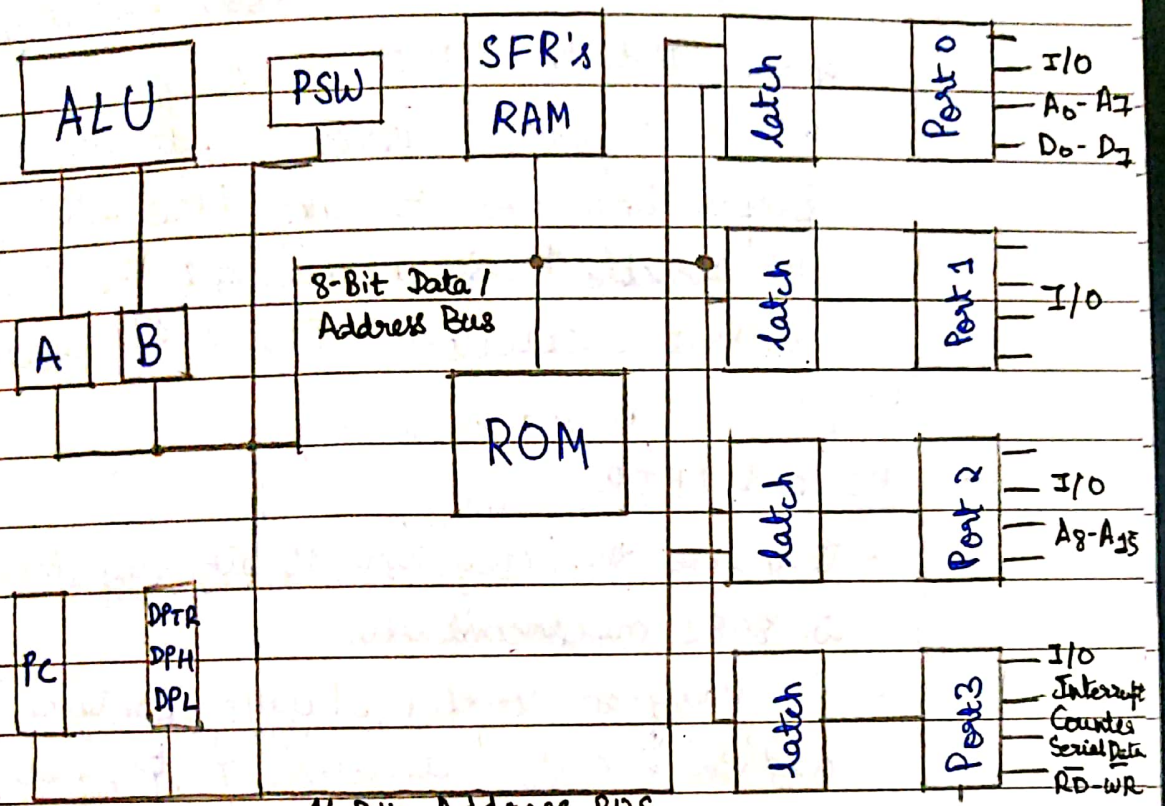
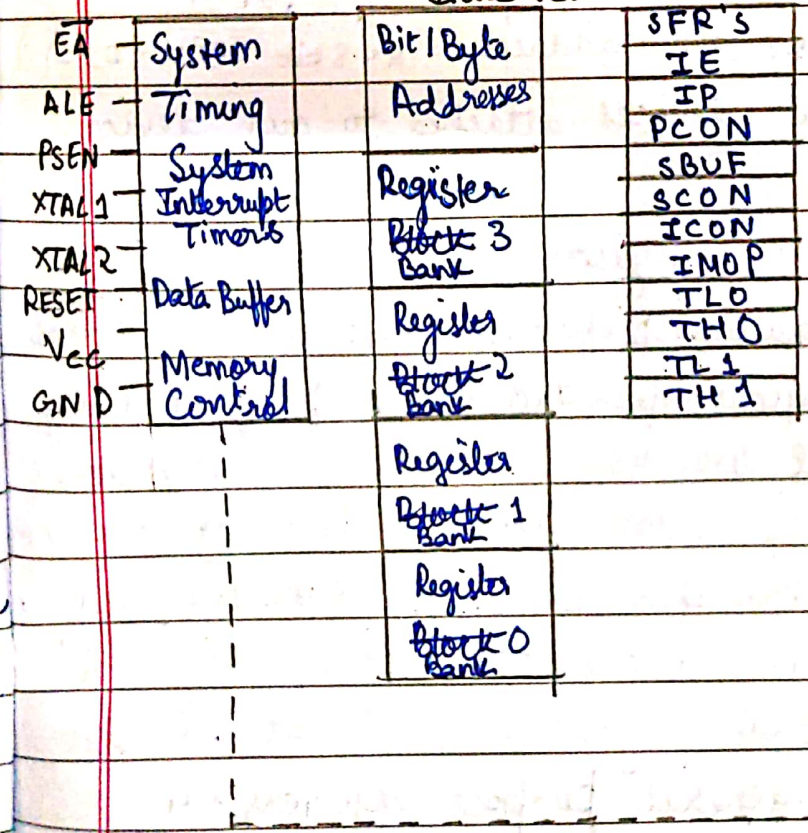
8051 Architecture



16 Bit Address BUS

Internal RAM Structure



→ **8051 Oscillator, Clock**

- 8051 consists of 2 internal oscillators and 3 external oscillators, whose frequency ranges from 1MHz to 16MHz.
- We fix crystal frequency to 12MHz, to use proper time; i.e., to make time 1µs. | 16MHz → < 1µs, <12mHz → > 1µs
- Not possible to synchronize all the tasks without oscillator. | Time α 1/frequency

→ **PC and DPTR**

- They are the only two 16 bit registers available in 8051 microcontroller.
- PC: Program counter always contains 16-bit address of next instruction to be executed.
- DPTR: Data Pointer is used to access external addresses (16bit address = 2× 8bit (DPH + DPL)) of external devices attached to our device.

→ **A and B CPU registers**

- All operations performed such as arithmetic and logical operations are performed by default we use 'A' and 'B' registers and also store data in them. They are CPU Registers
- Data transfer between external and internal devices are done using 'A' register
- A = 8 bit register. B = 8-bit register

★ 8 bit general purpose registers × 4
★ 2×16 bit registers : PC, DPTR

→ **Flags and PSW**

- Seven flags are present.
- Four special purpose flags, modified when arithemetic and logical operations are performed

i) Carry (CY) - Set when extra bit during addition, else reset

ii) Auxillary Carry (AC) - Used in BCD addition, set when carry is transferred from lower nibble to higher level, otherwise resel

iii) Overflow (OV) - Cannot store 256 in 8 bit register then overflow ~~oc~~ is set, else reset.

Overflow is detetted with: 9bit carry (carry into MSB) XOR 8th bit carry (carry out of MSB)

= 1 → overflow detected (set) = 0 → no overflow detected (not set)

9th bit ⊕ 8th bit

extra bit is generated — carry into MSB — carry out of MSB

1	1	0 → overflow not detected
0	0	
1	0	1 → overflow detected
0	1	

iv) Parity (P) - Always odd parity

No. of 1s in 8 bits + Parity bit = Odd no
↳ Parity Set

No. of 1s in 8 bits + Parity bit = Even no
↳ Parity reset

- Three special Purpose flags, can be access only by programmer, not by operations

i) GF0 (General Flag 0) ii) GF 1 (General Flag 1

iii) F0 (Flag 0)

- PSW is a special purpose register.

Applications:

- To check the status of flags.
- To modify the status of flags.
- To check which registers are under use.

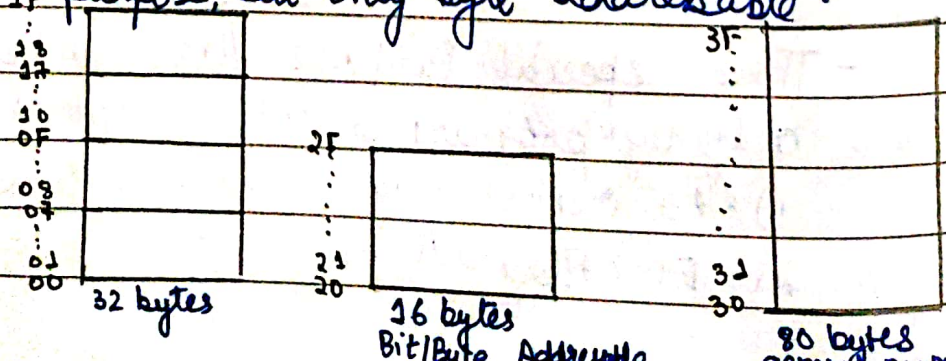
CY	AC	F0	RS1	RS0	OV	-	P

RS0	RS1		Register Bank
0	0	-	R.B.0
0	1	-	R.B.1
1	0	-	R.B.2
1	1	-	R.B.3

→ Internal Memory

Internal RAM:

- 128 bytes memory given to RAM.
- First 32 bytes given to register banks, each consists 8 registers (4×8=32) bit addressable
  (RB0 + RB1 + RB2 + RB3 = 8 + 8 + 8 + 8)
- After that, 16 bytes memory are accessed by bit addresses / byte addresses.
- Remaining 80 bytes are used for general purpose, but only byte addressable.



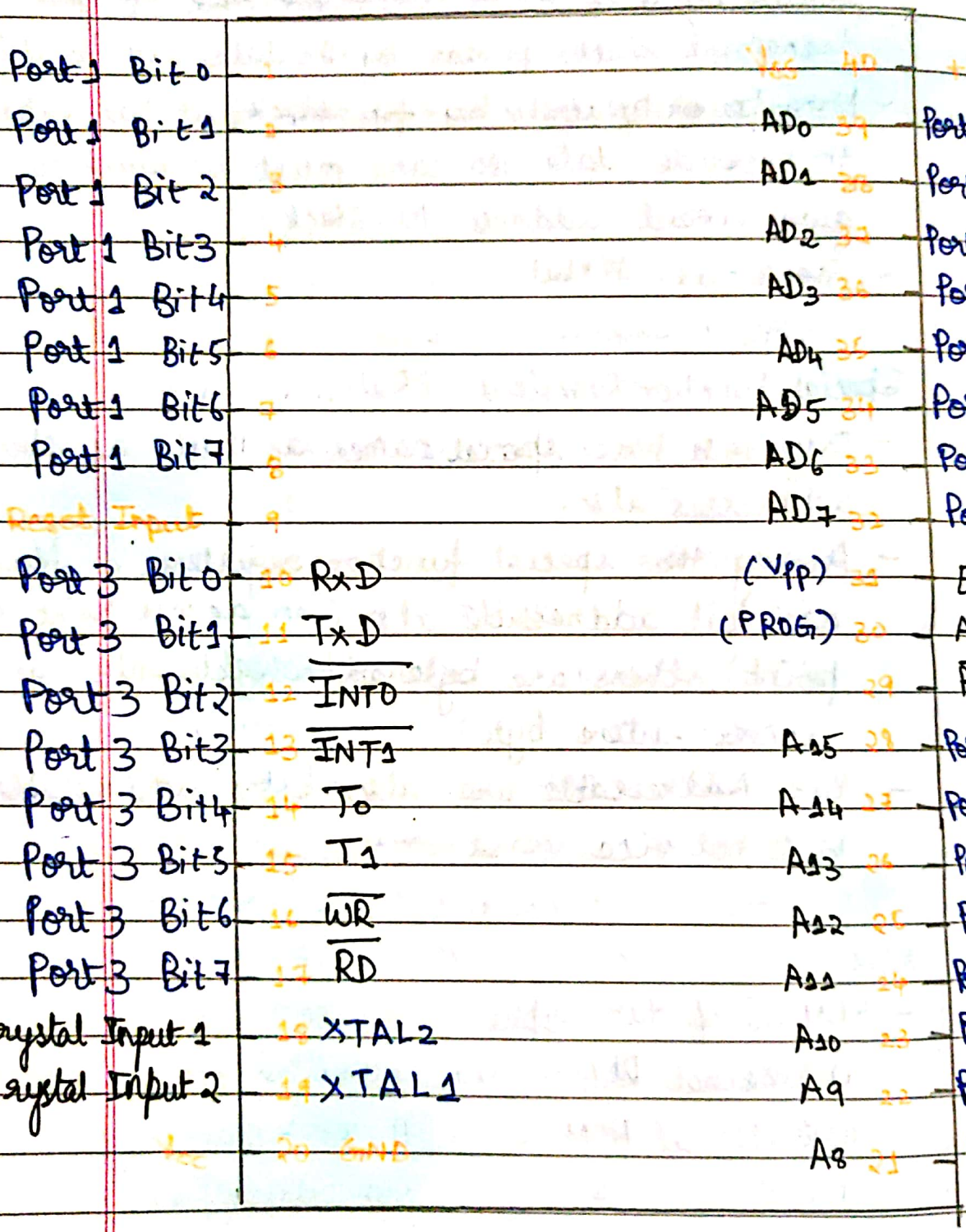
-Stack Memory : From internal memory, some part of RAM is used for stack pointer, increament the stack pointer by 1 if data is inserted, and if you decrement stack pointer by 1, data will be deleted.
- More priority will be for stack, it has capacity to override data, so care must be taken to give initial address to stack.
- Stack is 8 bit.

Special Function Registers (SFR's)
- They will have special names as well as special addresses also.
- Among the special function registers, a few are bit addressable also (can access point by point), others are byte addressable only (can access entire byte)
- Bit Addressable are also byte addressable, but not vice versa.

ROM
- ROM is of two types:
  i) Internal ROM
  ii) External ROM

★ Internal Memory
* Internal RAM
* Stack and SP
* Special Function Registers (SFR's)
* Internal ROM

8051 Microcontroller Architecture - 40 Pin Diagram



- Port 0, Port 1, Port 2, Port 3 - All pins can be used as i/p pins or o/p pins.
- Port 0, Port 2 can be used for dual purpose, i.e., accessing address and accessing data.
- Port 0 is used to access lower byte address [A0-A7]
- Port 2 is used to access higher byte address [A8 - A15]
- Port 3 has control pins Read, Write, Receive Data, Transmit Data.
- $\overline{RD}$ = 0 → Performing Read Operation
  $\overline{WR}$ = 0 → Performing Write Operation
- 8 x 4 = 32 Port Pins
- Other Pins:
  - Vcc - Ground Control
  - Vss - Frequency / Voltage
  - Crystal input 1 - } To provide frequency
  - Crystal Input 2 - } to device
  - Reset Input - To reset the microcontroller
  - EA
  - ALE
  - $\overline{PSEN}$

  } Access external RAM, ROM

- Addresses of Special Function Registers

A - 0E0	P0 - 80	PCON - 87	TCON - 88
B - 0F0	P1 - 90	PSW - 0D0	TL0 - 8A
DPH - 83	P2 - A0	SCON - 98	TH0 - 8C
DPL - 82	P3 - 0B0	SBUF - 99	TL1 - 8B
IE - 0A8		SP - 81	TH1 - 8D
IP - 0B8		TMOD - 89	

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Counters and Timers

→ TCON

TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0
7	6	5	4	3	2	1	0
001B		000B		0013 P3.3 INT1		0003 P3.3 INT0	

- Timers are used to calculate / count internal clock pulses.
- Clocks are used to calculate / count external clock pulses.
- Processor can also do all these, but if a processor has to do its own tasks and also couting, burden on processor is more.
- So, to reduce burden on processors, two hardware chips, externally added 16 bit registers, timers and counters are used.
- They are used as 2×8 bit registers
  TL0 + TH0 = Timer 0
  TL1 + TH1 = Timer 1
  L = Lower, H = Higher
- To find 'n' number of clock pulses, timer must be initialized with max − n + 1 value.
  Eg: Maximum = 10, we wan to count 5 events, timer must be initialized with 10 − 5 + 1 = 6

  (6) →1 (7) →2 (8) →3 (9) →4 (10) →5 (11)

  When overflow occurs, flag is set.
  When count comes to 0000, flag is set.

- We use '1' in max-n+1 because when the counter changes from FF to 00, the timer/counter counts that also, and we use that as interrupt.
- Whenever timer becomes 00, we use that as interrupt and can perform a particular task.
- Eg. 60 sec green light in traffic signals.
- Two special function registers
  Timer Control Register (TCON) and
  Timer Mode Register (TMOD)
  two 16 bit register control two timers.

TCON:

i) Timer Flag 1 (TF1)
ii) Timer Run 1 (TR1)
iii) Timer Flag 0 (TF0)
iv) Timer Run 0 (TR0)
v) Interrupt Edge 1 (IE1)
vi) Interrupt Signal Timer (IT1)
vii) Interrupt Edge 0 (IE0)
viii) Interrupt Signal Timer (IT0)

TCON is bit addressable, can change bit by bit in programming and also byte addressable.

* Timer 0 to count 'n', whenever Timer 0 moves from FF to 00, i.e., it overflows, TF0 becomes 1. Indicates counting completed.
* Timer 1 to count 'n', whenever Timer 1 moves from FF to 00, i.e., it overflows, TF1 becomes 1. Indicates counting completed.

* Both are reset / become 0 whenever microprocessor executes an interrupt service routine (whenever interrupts occur, automatically jump to particular address to execute task) present in address 001B (TF1) and 000B (TF0).

* TR1 is going to be set by programmer if we want to calculate internal clock pulses, i.e. (using T1 as timer) used for timing purpose.
* TR1=0 indicates we are not using timing, T1 does not work as timer.

* TR0 is going to be set by programmer if we want to calculate interal clock pulses, i.e., using T0 as timer, used for timing purpose.
* TR0=0 indicates we are not using timing, T0 does not work as timer.

* PCON Register
  Higher Nibble = Timer Flags
  Lower Nibble = Interrupt Flags

* IE1 - Wherever on P3.3 pin high to low (⎍) pin encountered, i.e., $\overline{INT1}$ pin of port 3 encounters change of high to low edge, it indicates internal interrupt occured, and IE1 is set, ~~otherwise reset~~..

* IE0 - Whenever on P3.3 pin high to low (↓) pin is encountered, i.e., $\overline{INT0}$ pin of port 3 encounters change of high to low edge, it indicates external interrupt has occured, IE0 is set.

* IE1=0 when process jumps to execute interrupt service routine at address 0013.
* IE0=0 when process jumps to execute interrupt service routine at address 0003.

* IT1 and IT0 are internal interrupts. User can set or reset them based on the task to be performed.

TMOD:

Gate	C/$\overline{T}$	M1	M0	Gate	C/$\overline{T}$	M1	M0
7	6	5	4	3	2	1	0
Timer 1				Timer 0			

- TMOD has two sets of four flags each, one set for Timer 0 and another set for Timer 1.
- The flags are duplicate ones. We can write only 4 bits.
- ~~The~~ TMOD is byte addressable, not bit addressable.
- Flags:
  i) C/$\overline{T}$: Counter/Timer ii, iii) M0, M1 - Mode Selection Bits
  iv) Gate - Gate Bit.

* $C/\bar{T}$ = Counter / Timer } Used to know whether we use it as timer / counter.

$C/\bar{T} = 0$ → Used as a timer

↳ Bit 6 = 0 => Timer 1 used as timer

↳ Bit 2 = 0 => Timer 0 used as timer

$C/\bar{T} = 1$ → Used as a counter

↳ Bit 6 = 1 => Timer 1 used as clock

↳ Bit 2 = 1 => Timer 1 used as clock

* M1 and M0 → Mode selection bits

Used when we use timers

Important when $C/\bar{T} = 0$, does not matter when $C/\bar{T} = 1$.

M1	M0	Timer Mode
0	0	0
0	1	1
1	0	2
1	1	3

- ~~Timer~~ Mode

* Gate Bit

- This device acts as a timer when we encounter conditions.
- When T0/T1 works in timer mode, i.e., used to clock internal clock pulses:

i) Timer 1/0 bit in TCON register must be 1 AND

ii) (a) Either gate bit in TMOD = 0 or

(b) Interrupt 1/0 must be 1.