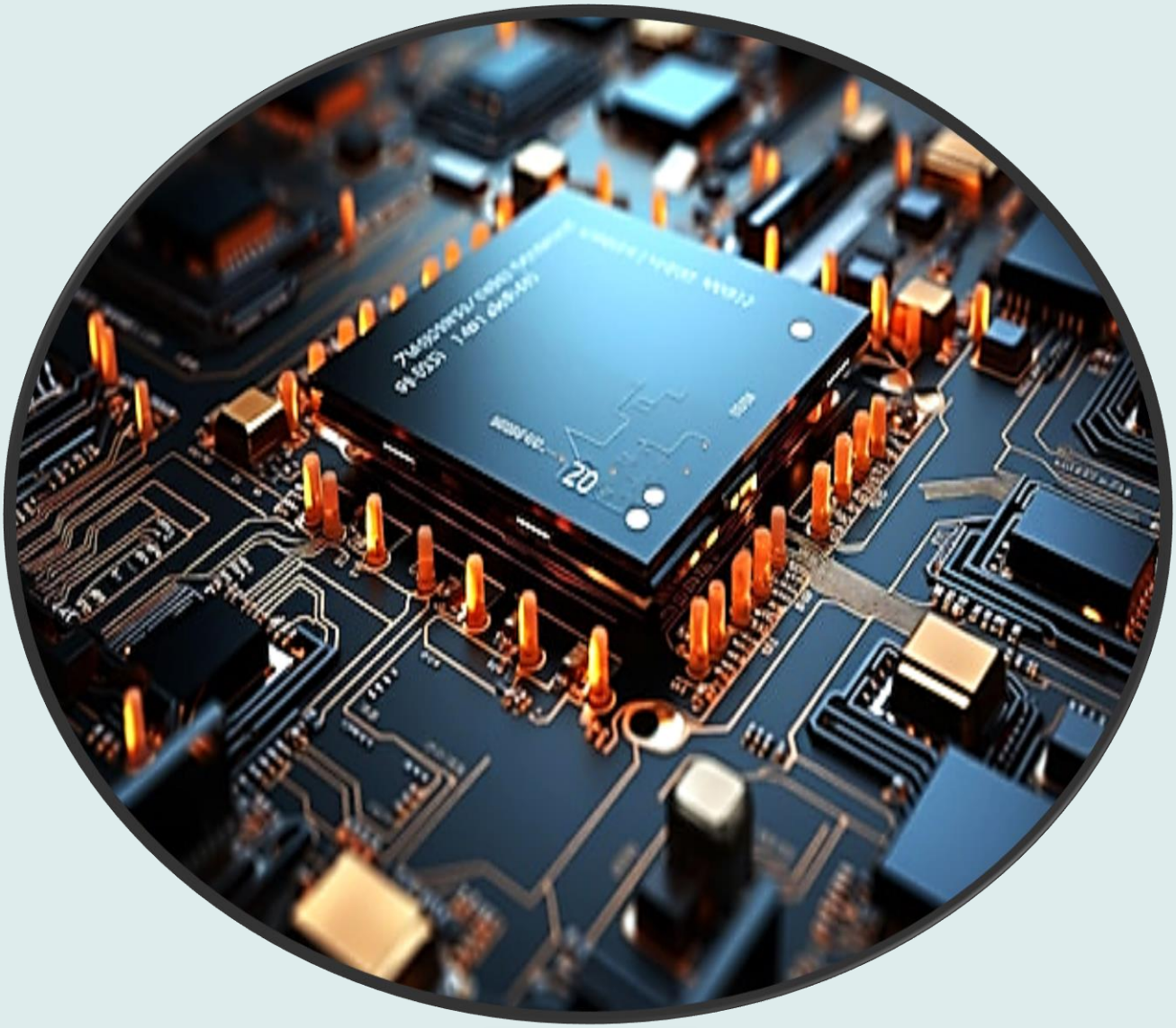


[REPORT]

ARCHITECTURE OF 8051 MICROCONTROLLER

Microcontrollers are generally dedicated for specific applications. A microcontroller may take an Input from the device it is controlling and controls the device by sending signals to different components in the device. Microcontrollers normally contains a processor, memory, serial ports, and necessary logic circuits to perform the specific function. The more popular microcontrollers are of 8-bit types. The INTEL corporation was designed a 8-bit microcontroller, well known as 8051. Later several manufacturers had been introduced number of chips in the 8051 series differing in terms of memory type and capacity, number of counters/timers, clock rates, number of ports etc. However, all such developments are only the extensions on core 8051 microcontroller In this report the internal arrangement of 8051, functions of each block, and how they are connected one to another are explained chip for its CPU.

[REPORT]

ARCHITECTURE OF 8051 MICROCONTROLLER

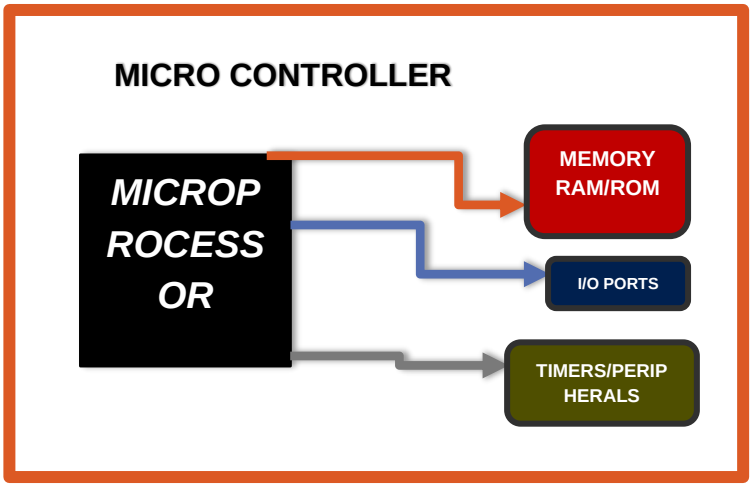
While studying microprocessor based system design, one may note that a stand-alone microprocessor is not self-sufficient. It requires other components like memory and input/output devices to form a minimum workable system configuration. Rather, one may infer that in addition to a microprocessor, the memory and I/O ports are integral parts of a practical system. To have all these components in a discrete form and to assemble them on PCB. Is usually not an affordable solution for the following reasons:

- **The overall system cost of a microprocessor-based system built around a CPU, memory and other peripherals is high as compared to a microcontroller based system.**
- **A large sized PCBs is required for assembling all these components, resulting in an enhanced cost of the system.**
- **Design of such PCBs require a lot of effort and time and thus the overall product design requires more time**
- **Due to the large size of the PCB and the discrete components used, physical size of the product is big and hence it is not handy.**
- **As discrete components are used, the system is not reliable nor is it easy to trouble shoot such a system.**

Considering all these problems, intel decided to integrate a microprocessor along with i/o ports and mini- mum memory into a single package. Another frequently used peripheral, a programmable timer, was also integrated to make this device a self-sufficient one. This device which contains a microprocessor and the above mentioned components has been named a microcontroller. A microcontroller a microprocessor with integrated peripherals. The introduction of microcontrollers drastically changed the microprocessor based system design concepts, specially in case of small dedicated systems. Design with microcontrollers has the following advantages:

- As the peripherals are integrated into a single chip, the overall system cost is very low.
- The size of the product is small as compared to the microprocessor based systems thus very handy.
- The system design requires very little efforts and is easy to troubleshoot and maintain.
- As the peripherals are integrated with a microprocessor, the system is more reliable.
- Though a microcontroller may have on-chip ram, rom and i/o ports, additional RAM, ROM and ports may be interfaced externally, if required.
- The microcontrollers with on-chip rom provide a software security feature which is not available with microprocessor-based systems using ROM/EPROM

However, in case of a larger system design, which requires more number of i/d ports and more memory capacity the system designer may interface external i/o ports and memory with the system. In such cases, the microcontroller-based systems are not so attractive as they are in case of the small dedicated systems. As a microcontroller contains most of the components required to form a microprocessor system, it is sometimes called a single chip microcomputer. Since it also has the ability to easily implement simple control functions, it is most frequently called a microcontroller. In this chapter, we will briefly present intel's 8-bit microcontroller family, popularly known as mcs-51 family. In the end, we will introduce the architecture and general features of intel's 16-bit microcontroller family called 8051.



FEATURES

- It is a 40-pin IC chip available in Dual In line Package.
- It requires + 5V power supply.
- It has four register banks.
- It has 32 I/O lines.
- It has one serial port.
- • It has four numbers of parallel ports.
- It has 128 Bytes internal RAM.
- It has 4 KB internal ROM
- It has two numbers of Timers/Counters.
- It has 34 numbers of 8-bit .
- It has 2 numbers of 16-bit registers. (PC, DPTR)

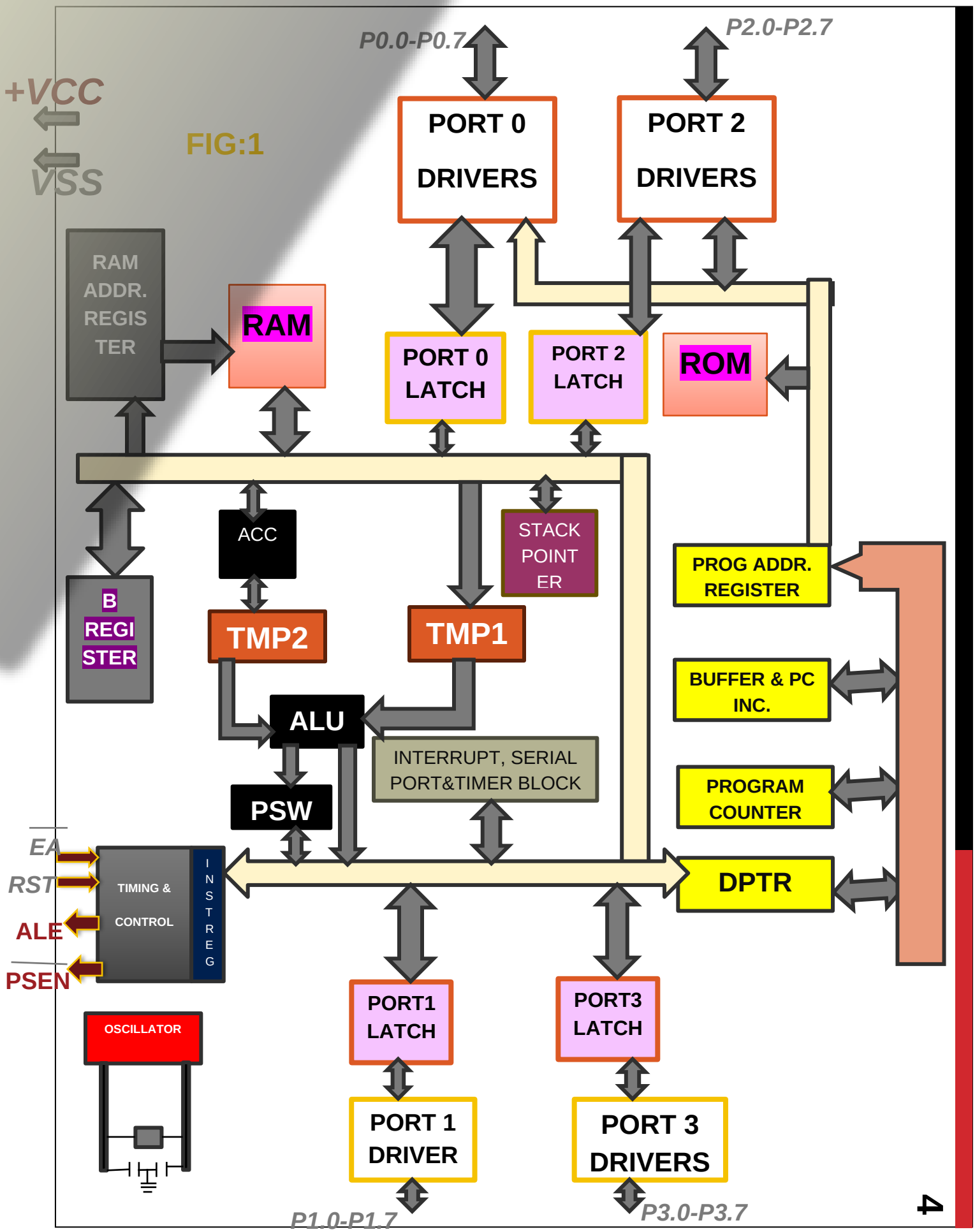

+VCC
VSS
P0.0-P0.7
P2.0-P2.7
PORT 0 DRIVERS
PORT 2 DRIVERS
RAM ADDR. REGISTER
RAM
PORT 0 LATCH
PORT 2 LATCH
ROM
ACC
STACK POINTER
PROG ADDR. REGISTER
B REGISTER
TMP2
TMP1
BUFFER & PC INC.
ALU
INTERRUPT, SERIAL PORT&TIMER BLOCK
PROGRAM COUNTER
PSW
EA
RST
ALE
PSEN
TIMING & CONTROL
INSTREG
DPTR
OSCILLATOR
PORT1 LATCH
PORT3 LATCH
PORT 1 DRIVER
PORT 3 DRIVERS
P1.0-P1.7
P3.0-P3.7

FIG:1

The 8051 is a 40-pin chip with NMOS (N-channel metal oxide silicon) technology The Architecture of 8051 can be represented in several ways. One of the schematic views shown in Fig. 1

The functions of each block is explained below:

1. Central Processing Unit (CPU): The CPU of 8051 is capable in performing arithmetic and logical operations like addition, subtraction, multiplication, division. logical AND, OR, EX-OR, rotate, clear and complement. This CPU can do bit wise as well as byte wise manipulations: The 8051 contains several registers, such as accumulator, B register, Data pointer, Program counter, Stack pointer, and Program Status-word (PSW).

2. Internal Memory: In general CPU requires program codes and relevant data while performing a task. In order to make them available the 8051 has two types of internal memories, ie., RAM and ROM.

- The I-RAM is of **128** bytes. It is divided into three parts, such as
  - 32 registers in four banks of '8' each
  - 16registers-bit addressable.
  - 88 registers byte addressable.
- The I-ROM is of **4 KB** in size ranging from 0000H to OFFF H.

3. Special Function Registers: The 8051 has several Special Function Registers (SFRs) known **as A, B, DPTR, PSW, IP, IE, TCON, SCON, PCON, P0, P1, P2, P3, SBUF e**tc. All these are byte addressable and some of them are bit addressable also. The SFRs can be accessed by their names or by their addresses. These are useful in accessing I/O Ports, timers/counters, UART, Power Controlling etc.

4.Timers/Counters: The 8051 has two timers/counters. Many micro controller applications are requires the counting of external events happened around the micro controller or in maintaining the time delays between the actions occurred inside of the micro controller Counters are used to count the events where as timers are used to maintain time delays between the actions This unit has two 16-bit registers named as To & T1. Since the 8051 is a 8-bit controller, these registers are also byte addressable ie, low byte and high byte **(TL0, TL1, TH0,**

TH1). Two SFRS TMOD and TCON are used to monitor the nature of work the said registers T0 & T1.

5. Serial Port: This unit provides serial data transfer. This feature is required i certain communications with other computers and while accessing with some peripherals like Printer. A SFR known as SBUF is used to hold the data before and after serial data transfer. **Two other SFRs, SCON and PCON** are used to determine the baud rate, transmission reception, etc. In fact, SBUF has two 8-bit registers, one for holding the data while transmission. Another register receives the data and carries during reception The serial data communion can be held in one of the four modes.

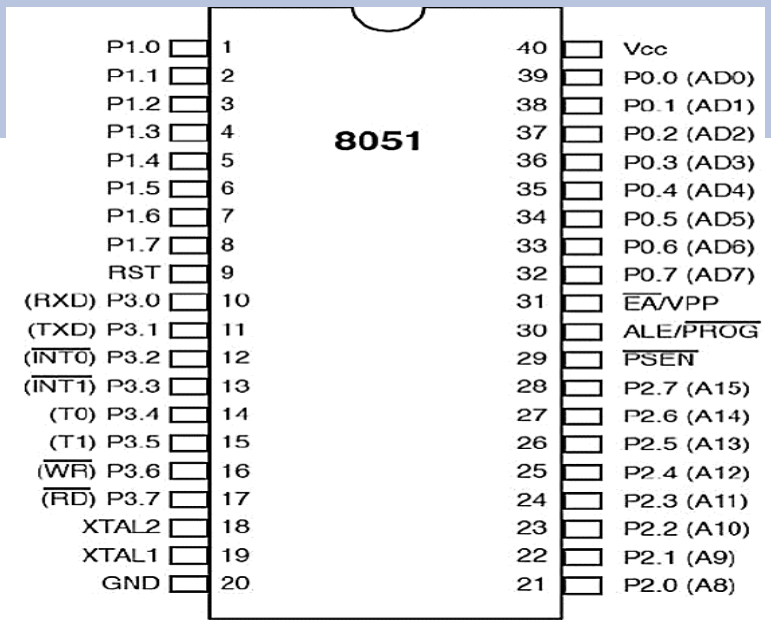
6. Interrupt Control: This unit alters the micro controller's attention from one task to some other. This may happens whenever an interrupt input become active. Interrupts may generate in the inside of the 8051 or provided from the external sources.The 8051 has five interrupts, such **as IFO, TF1, INTO, INT1, and R1/T1** These interrupts either all or selectively enabled disabled through a SFR ‘IE’ Further the priority among these can be determined by another SFR ‘IP’.

7. I/O Ports: In 8051, there are four 1/0 ports with 8 lines of each. Some of these ports can be configured as an Input or as an Output port. In addition, **port 3** performs some specified functions. Special circuits like latch, buffer, driver are built in these ports to perform the said actions.

8. Oscillator and Clock: In order to synchronize all the internal operations of the micro controller, an on-chip oscillator is used. However, requires an external oscillator to run the on-chip oscillator. A quartz crystal oscillator is connected as an input to the said purpose. The 8051 designs are available with wide range of frequencies. Typically, from **1MHz to 16MHz.**

9. Ports:

The ports can be easily understandable by using the pin diagram of the 8051 microcontroller



- **P1.0 - P1.7:** A total of 8 lines names as port) and used for input or output

- **P 3.0-P 3.7:** A total of 8 lines named as port-3 and used for Input or output. In addition, these lines provide special functions, as listed below.

- P 3.0 (RxD): Data received in Serial form.
- P 3.1 (TxD): Data transmitted in Serial form.
- P 3.2 (INTO): A hardware interrupt of vectored location 0003 H.
- P 3.3 (INTI): A hardware Interrupt of vectored location 0013 H.
- P 3.4 (T0): Pulse input given to the Counter-0.
- P 3.5 (T1): Pulse input given to the Counter-1.
- P3.6 (WR): A control signal to activates memory (I/O device) for write operation.
- P3.7 (RD): A control signal to activates memory (I/O device) for read operation.

- **(XTL1 and XTL2**): A quartz crystal oscilliator and capacitors formed as a pulse generator and is connected to Inputs XTAL1 and XTAL2 to run the on-chip oscillator.

- **P 2.0-P 2.7 (A8 – A15)** : A total of 8-lines named as port-2 and used for input and output. In addition, these lines provides high order address byte (A8 - A15) through which the 8051 can access 64 K bytes memory .

- **(PSEN):** "Program Store Enable" is an output pin used to access the external program memory (ROM) while connecting it to ' OE' terminal of ROM chip.

- **(ALE): "**Address Latch Enable" is an output pin used to latch the low order address byte (A0 – A7) This is for demultiplexing the address and data.

- **(EA) :** "External Access" is an input pin used to access the external program code memory (ROM) only. If this is at VCC level then the 8051 can access 4 K bytes of internal ROM (0000 HOFFF H) and when it is connected to ground it access external ROM of 60K bytes (1000H-FFFFH). enable/disable the external.

- **P0.0-P0.7 (AD0 - AD7) :** A o total of 8 lines named as Port-0 and used for input and output. In addition these lines also provides a dual function carrying of address (low order byte) and data (D0 - D7) ALE pin indicates that these lines are having either address or data. When **ALE = 1** these lines represent the low order address byte otherwise data byte.

- **RESET:** Active HIGH input used to reset the micro controller and terminate all activities.

DO YOU KNOW?

- Microcontroller architectures are categorized by their data bus width, determining the volume of data processed in a single instruction cycle. The most prevalent architectures include: **8-bit,16bit,32bit.**
- There are numerous microcontroller families available, each with its own unique features and capabilities. Some popular microcontroller families include: **Atmel AVR, Microchip PIC, ARM Cortex**
- **Microcontrollers (often shortened to MCUs or MCs) are extremely small microcomputers that are entirely self-contained on a single chip.**

- **Vcc:** This is a +5 V supply voltage pin.
- (**GND):** This is a return (Ground) Pin for the supply.

❖ **Some of the most common microcontrollers are:**

- Microchip Technology PIC microcontrollers (8-bit PIC16, PIC18, 16-bit dsPIC33, PIC24, 32-bit PIC32)
- Freescale ColdFire (32-bit) and S08 (8-bit)
- Intel 8051 microcontrollers
- PowerPC ISE
- Renesas Electronics (RL78 16-bit MCU, RX 32-bit MCU, SuperH, V850 32-bit MCU, H8, R8C 16-bit MCU)
- Silicon Laboratories Pipelined 8-bit 8051 microcontrollers and mixed-signal ARM-based 32-bit microcontrollers
- Texas Instruments TI MSP430 (16-bit), MSP432 (32-bit), C2000 (32-bit)
- Toshiba TLCS-870 (8-bit and 16-bit)
- CISC and RISC (also RISC-V)

❖ **The microcontroller has been widely used in various real-time applications due to its simple architecture, ease of programming and cost effectiveness. Some of the real time applications include:**

- Washing machines
- Microwave ovens
- Television remote controls
- Robotic arms in industrial automation
- Car alarm systems
- Traffic light control systems
- Smart card readers
- **Digital clocks and timers**
- Stepper motor controllers
- Automatic door control systems
- Electronic voting machines
- Embedded systems for sensors and actuators
- Power management systems in devices
- Uninterruptible power supplies (UPS).
- Temperature & Basic engine control units (ECUs) in automobiles
- Medical devices (e.g., glucose meters, blood pressure monitors)