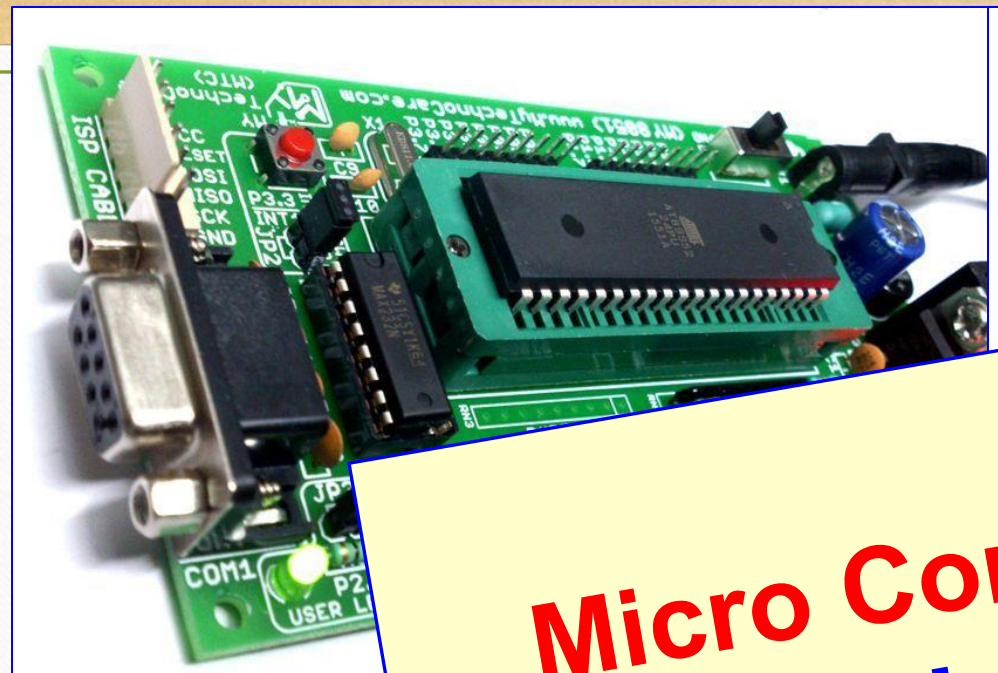
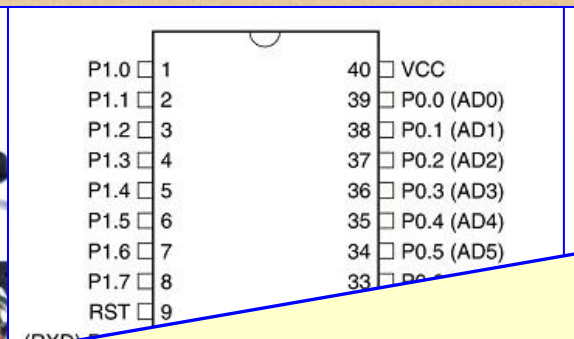
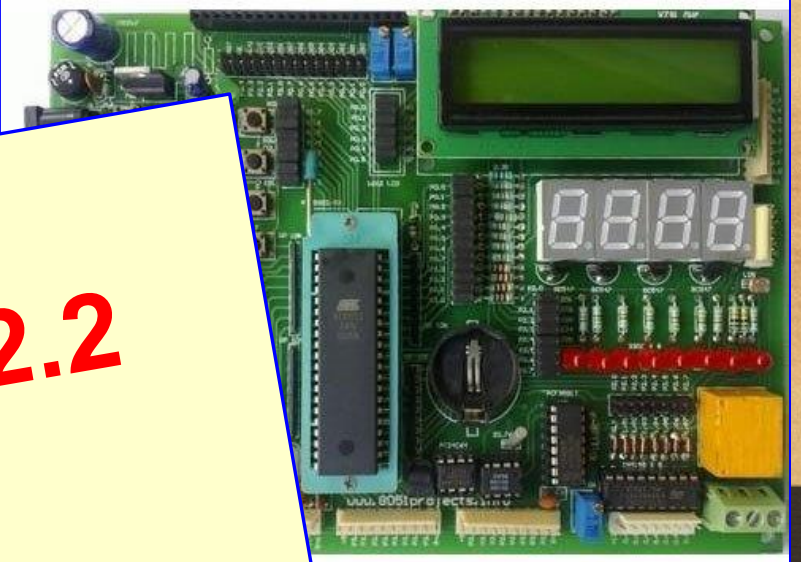
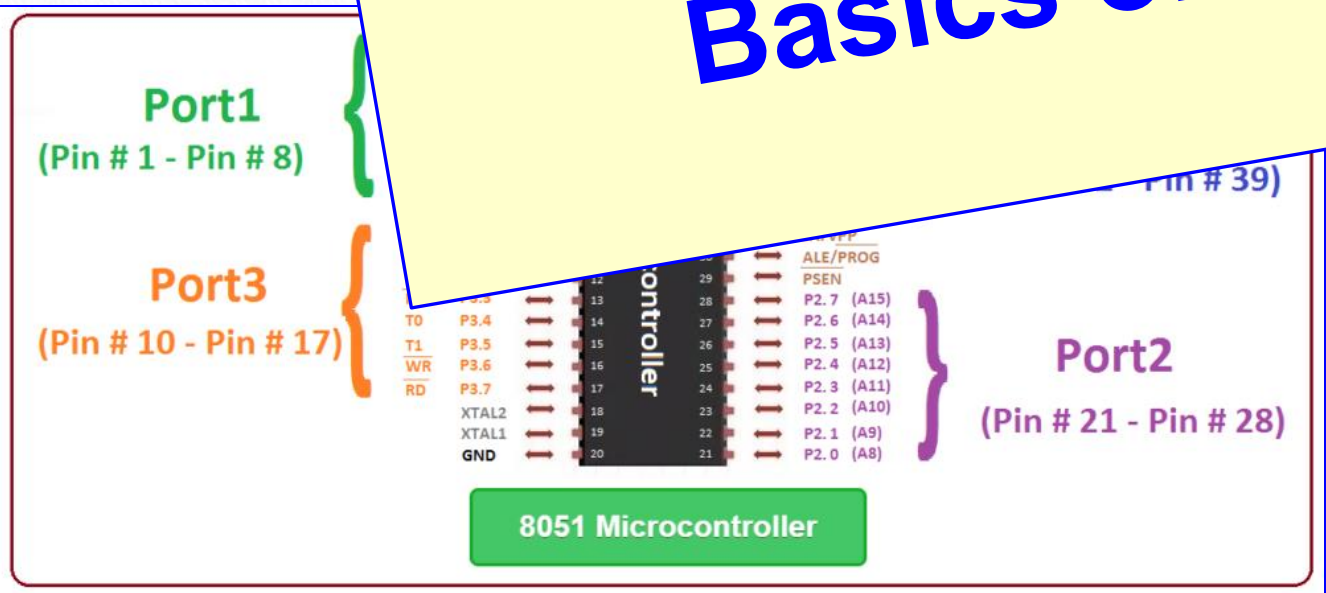
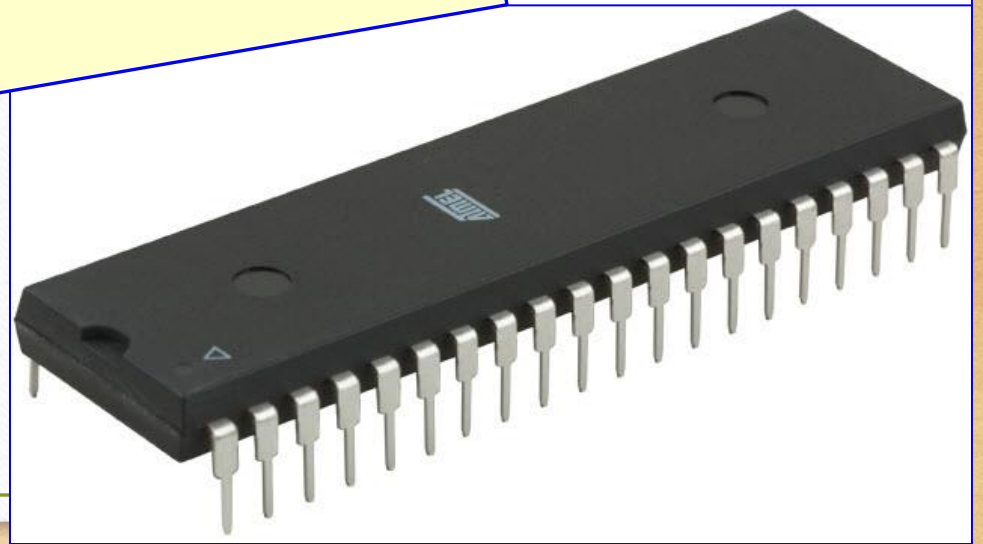


# Micro Controllers – 2.2
# Basics of 8051



# Mechatronics & Robotics

## A quick glimpse of Microcontroller 8051

# What do you mean by a micro-controller ?

- ✓ It's like a small computer on a single IC chip.
- ✓ It contains a processor core, ROM, RAM, I/O pins, communication pins etc.
- ✓ it has almost all the components needed in its single chip.
- ✓ It does not need any external circuits to do its given task.
- ✓ examples are …. 8051, AVR, PIC series of microcontrollers.

# Why to study of 8051 micro-controller ?

- ✓ This is the first “All in one” chip introduced by Intel in 1980 under the name MCS-51 popularly known as 8051.
- ✓ It is referred as “system on a chip”. It has 128 bytes of RAM, 4K bytes of on-chip ROM, 2 timers, 1 serial port and 4 ports (8-bit wide), special function registers ….. all on one single chip.
- ✓ Other variants of 8051 are 8052 and 8031.

# Important features of 8051 micro-controller

- ✓ 4KB bytes on-chip program memory (ROM)
- ✓ 128 bytes on-chip data memory (RAM)
- ✓ Four register banks
- ✓ 128 user defined software flags
- ✓ 8-bit bidirectional data bus
- ✓ 16-bit unidirectional address bus
- ✓ 32 general purpose registers each of 8-bit
- ✓ 16 bit Timers (usually 2, but may have more or less)
- ✓ Three internal and two external Interrupts
- ✓ Four 8-bit ports,(short model have two 8-bit ports)
- ✓ 16-bit program counter and data pointer
- ✓ 8051 may also have special features such as UARTs, ADC, Op-amp, etc.

# Important terms used in a micro-controller

1) Registers –

2) Pins and Ports –

3) Oscillator, Clock, Crystal –

4) Internal and External Memory –

5) Program Counter, Data Pointer –

6) Counters and Timers –

# Important terms used in a micro-controller

7) Address bus and Data bus –

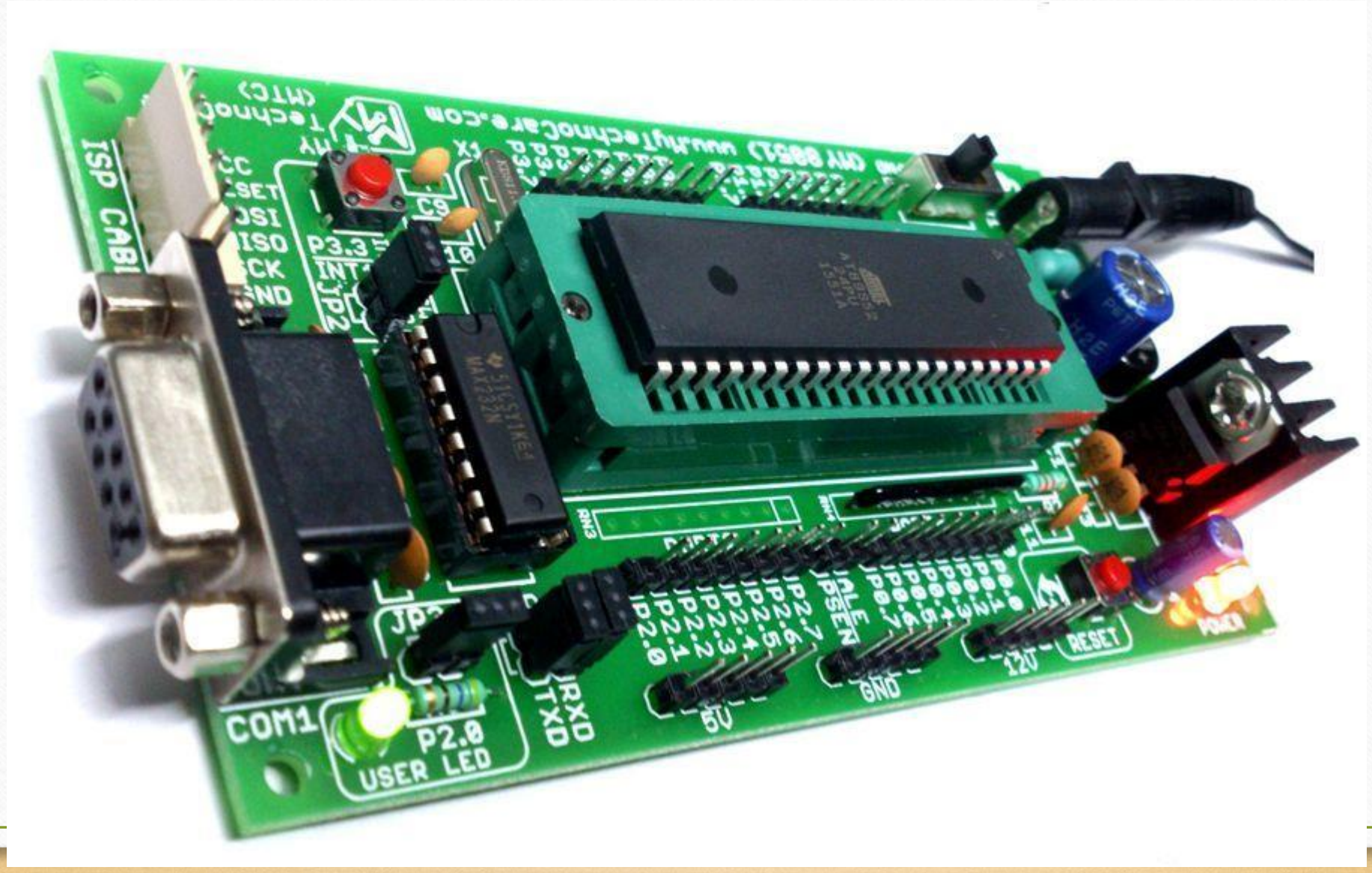
8) Stack and Stack Pointer –

9) Flags and PSW –

10) ADC and DAC –

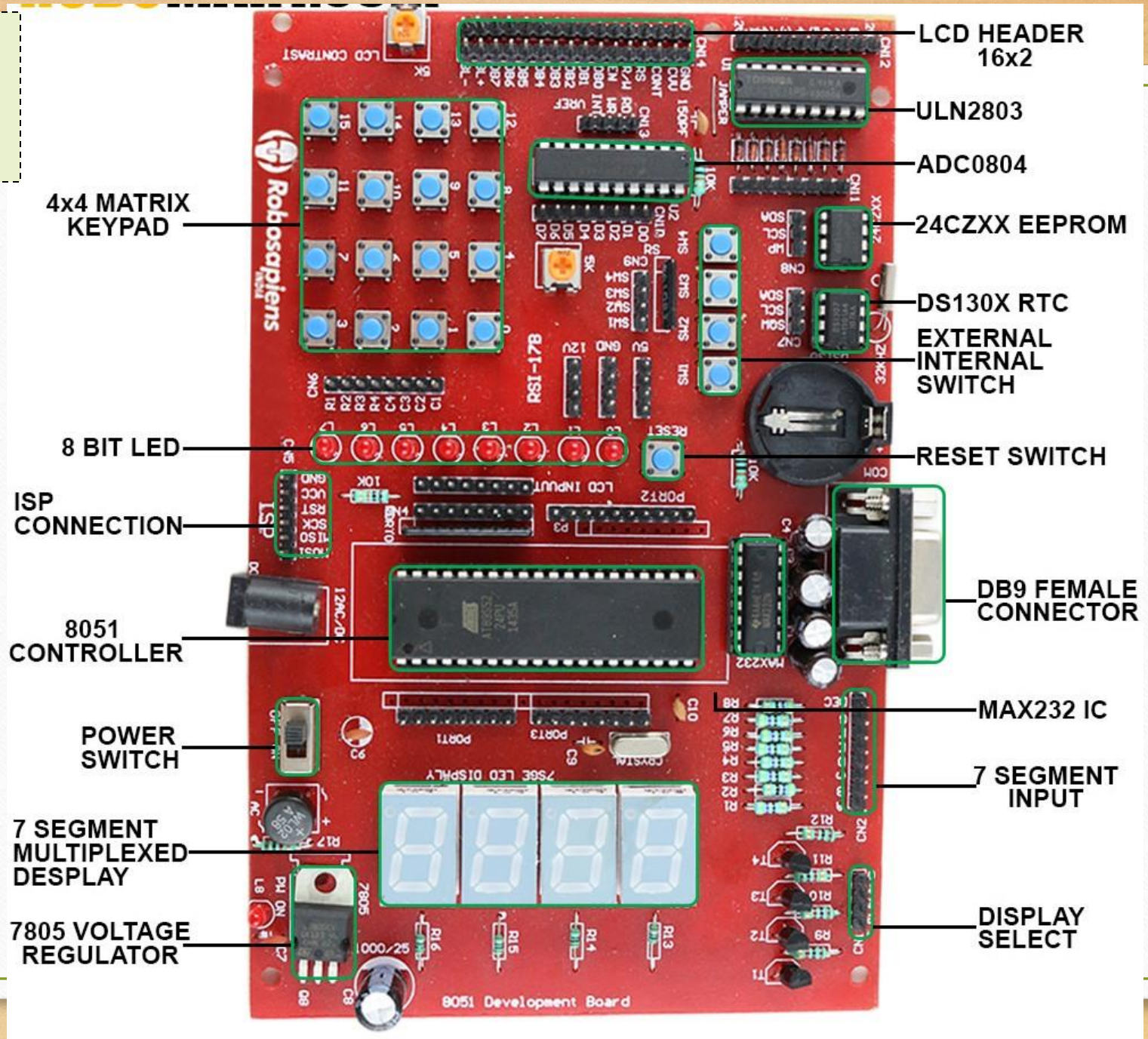
11) Interrupts –

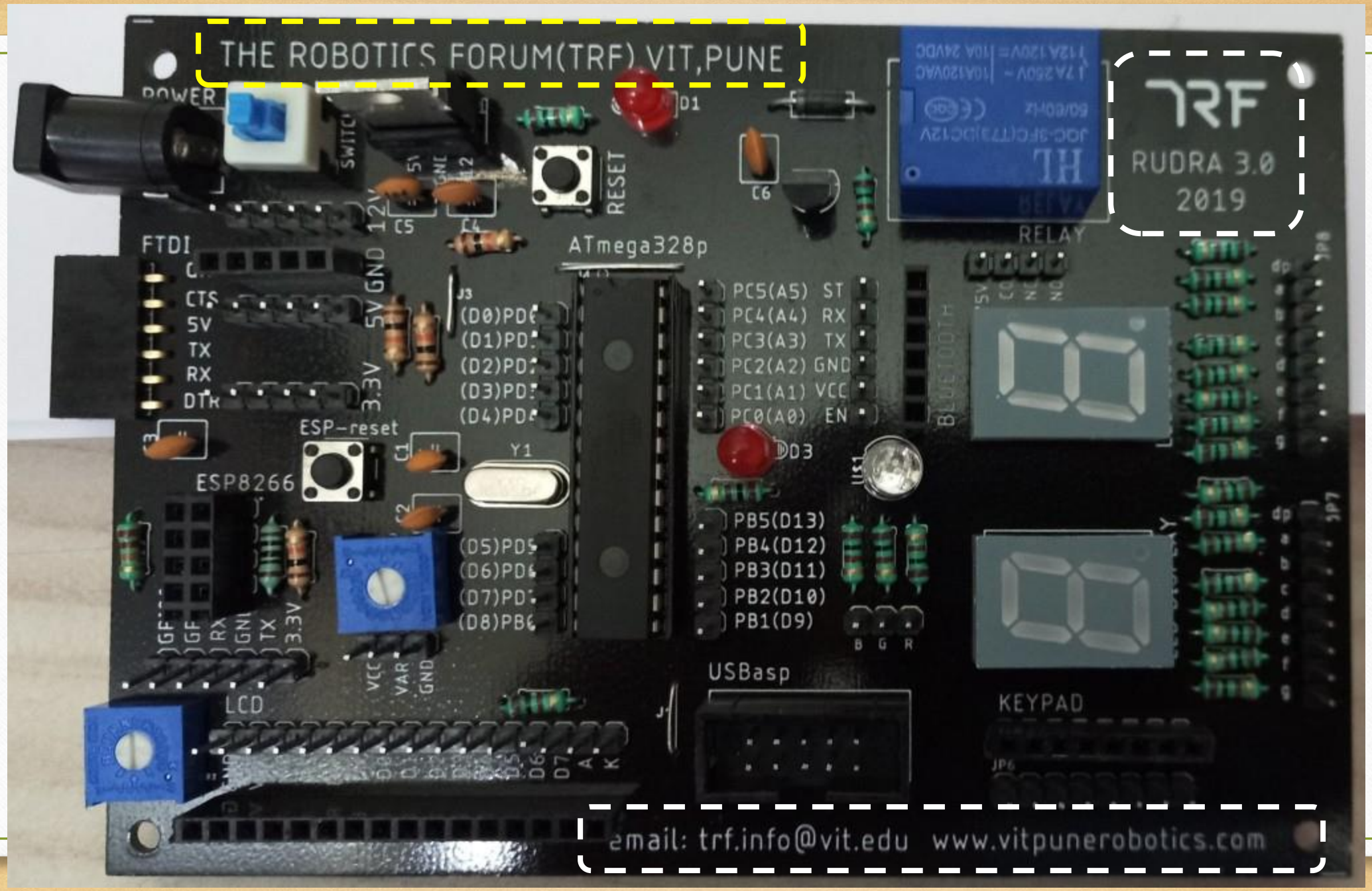
# Development board

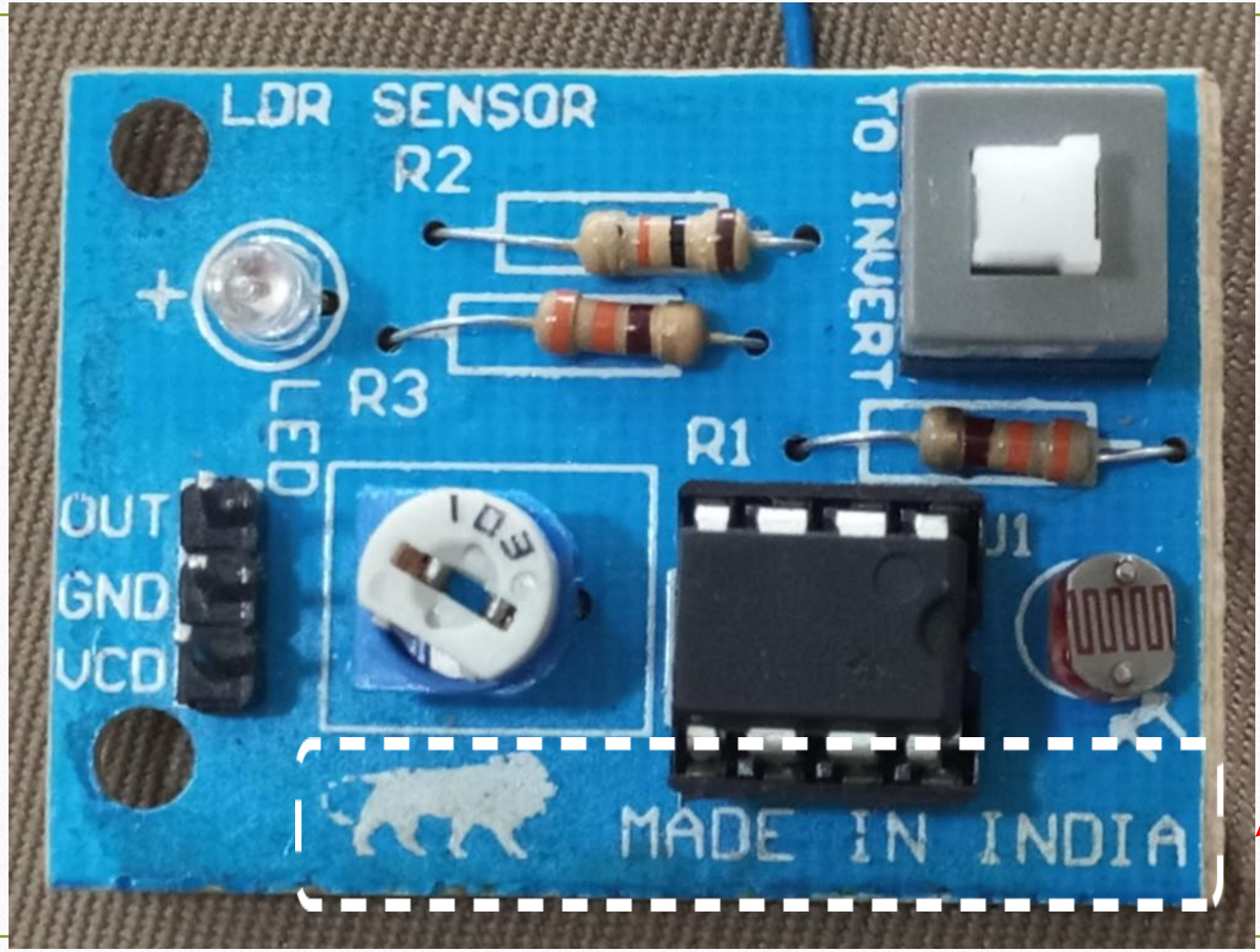


# Development board

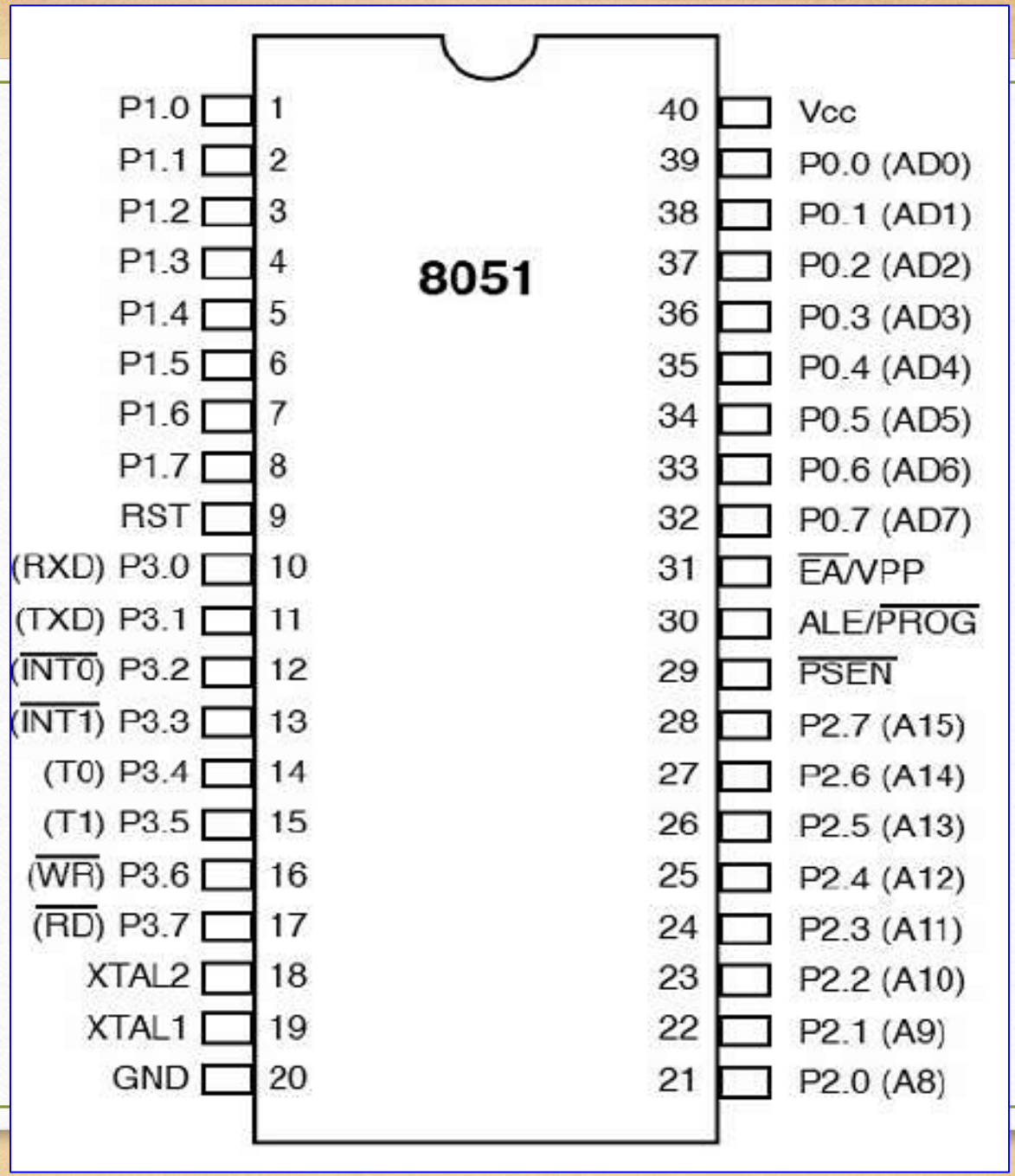
# Development board



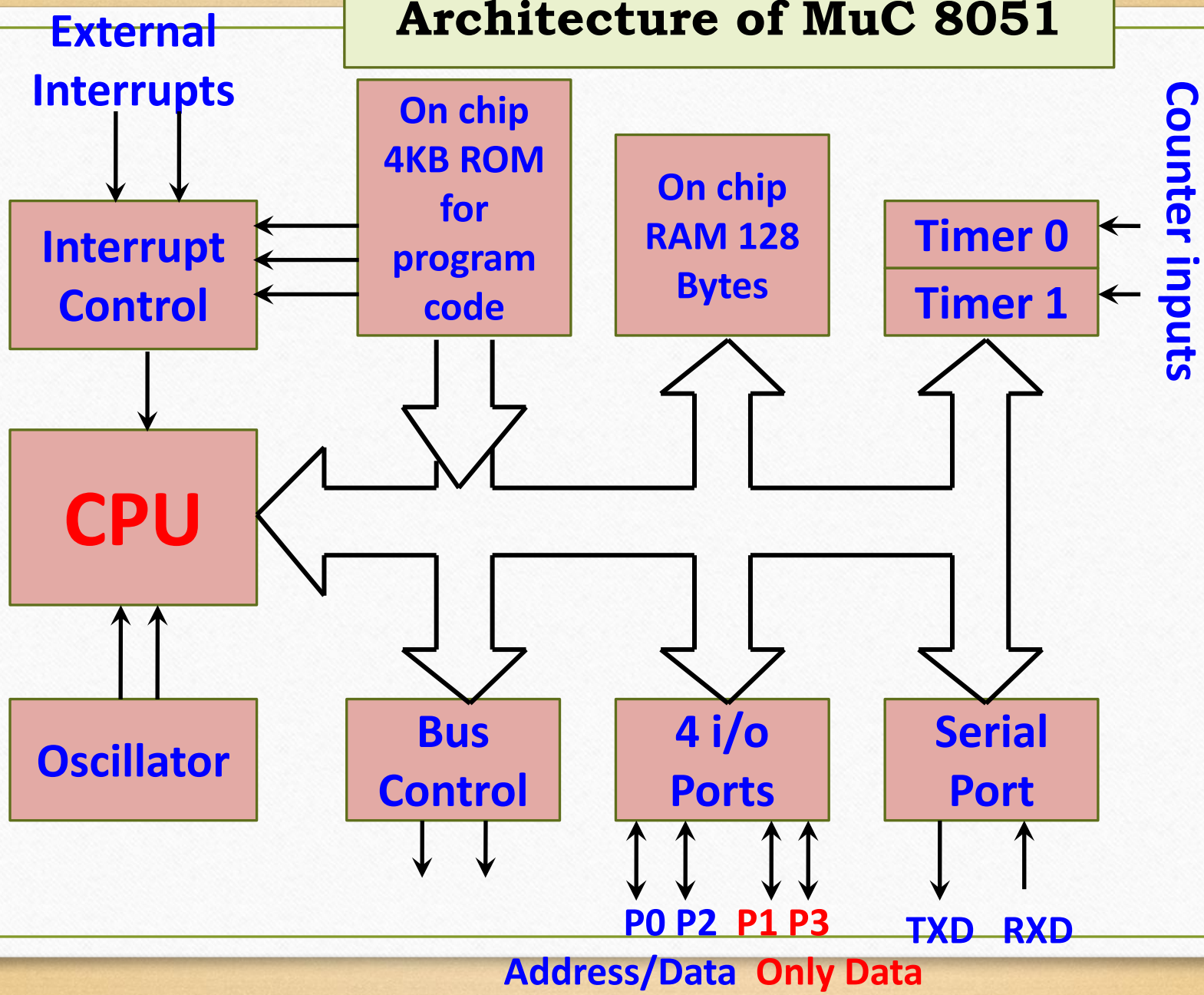

THE ROBOTICS FORUM(TRF) VIT,PUNE
TRF
RUDRA 3.0
2019
POWER
SWITCH
RESET
FTDI
ATmega328p
RELAY
BLUETOOTH
ESP-reset
ESP8266
LCD
USBasp
KEYPAD
PC5(A5) ST
PC4(A4) RX
PC3(A3) TX
PC2(A2) GND
PC1(A1) VCC
PC0(A0) EN
PB5(D13)
PB4(D12)
PB3(D11)
PB2(D10)
PB1(D9)
email: trf.info@vit.edu www.vitpunerobotics.com


LDR SENSOR
R2
R3
R1
TO INVERT
OUT
GND
VCD
J1
MADE IN INDIA

# Pin diagram of 8051



# Architecture of MuC 8051



# Important terms used in a micro-controller

**Registers –** A register is a place in a CPU that can store small amounts of the data used for performing various operations such as addition and multiplication and loads the resulting data on main memory. Registers contain the address of the memory location where the data is to be stored.

**Pins –** Input and Output Pins on the MuC

**Ports –** Different Groups of Pins having similar or common characteristics

# Important terms used in a micro-controller

**Crystal –** The basic frequency of a Quartz Crystal.

**Oscillator –** is formed by a Crystal, Capacitors and an Inverter circuit that generates a train of pulses.

**Clock –** A clock generates pulses to which all internal operations are synchronised.

**Internal and External Memory –** Huge connections and networks of Flip-Flops are used to generate memory.

# Important terms used in a micro-controller

**Program Counter (PC) –** It is a special-purpose register that is used by the processor to hold the address of the current and the next instruction to be executed. The PC has no. of bits equal to the bits required for the address of the memory location.

**Data Pointer (DPTR) –** Data Pointer is used for pointing to data. It is used by the 8051 to access external memory using the address indicated by DPTR.

# Important terms used in a micro-controller

**Counters and Timers –**

**Timer** generates a time delay using the frequency of the internal clock.

**Counter** counts no. of pulses of an event happening outside the microcontroller.

The MuC 8051 has two counters / timers which can be used either as a Timer or as a Counter.

# Important terms used in a micro-controller

**Flags and PSW –** The Flag register is the status register in a MuC that contains the current status of the MuC and indicates the status by setting or resetting a particular bit.

Flags are the bits in special function registers which generate an interrupt under specific conditions when the programmer enables them.

# Important terms used in a micro-controller

**Stack** – The stack is a section of RAM used by the CPU to store a temporary information which could be a Data or an address during program execution.

**Stack Pointer** – The register used to access the stack is called stack pointer register which is a small register used to point at the stack.

# Important terms used in a micro-controller

**Interrupt –** An interrupt is a signal to the processor emitted by h/w or s/w indicating an event that needs immediate attention.

Whenever an interrupt occurs, the controller completes the execution of the current instruction and jumps to start execution of an Interrupt Service Routine (ISR) or Interrupt Handler.

When an interrupt is generated, the processor saves its execution state and begins executing the interrupt handler.

The IVT (Interrupt Vector Table) points to the ISR to be executed.

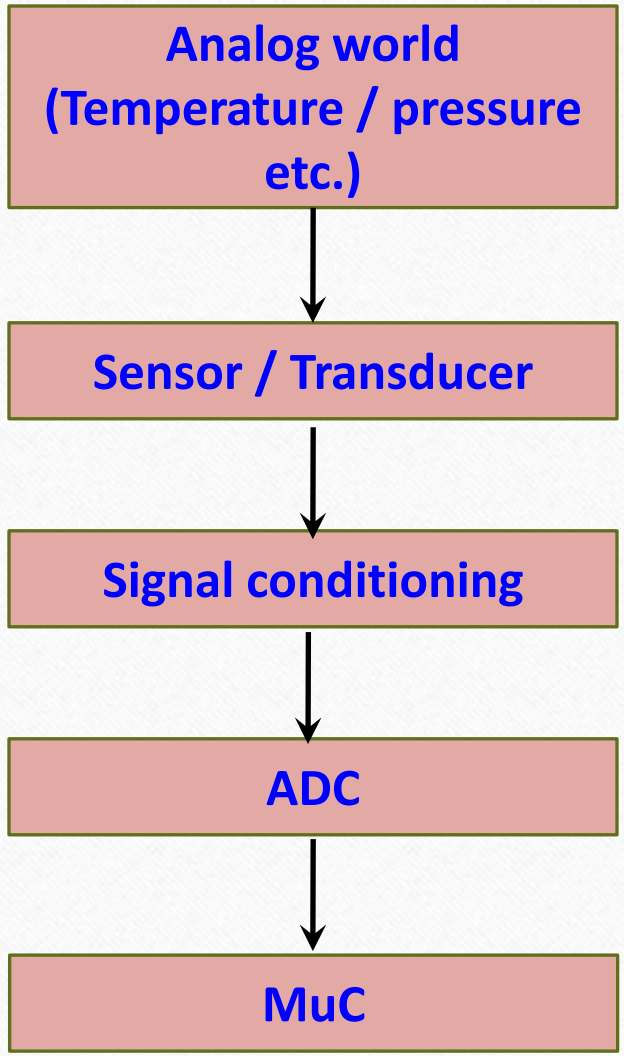
# Important terms used in a micro-controller

**Address Bus –** It is a group of wires or lines that are used to transfer the addresses of Memory or I/O devices. It is **unidirectional.** The width of the address bus determines the number of memory locations CPU can address.
For e.g. a system with a 16-bit address bus can address $2^{16}$ memory locations. i.e. 65536 memory locations.

**Data Bus –** This is used to transfer data within the Microcontroller and Memory to i/o devices. It is **Bidirectional** as the MuC needs to **send** or **receive** the data.

# Important terms used in a micro-controller

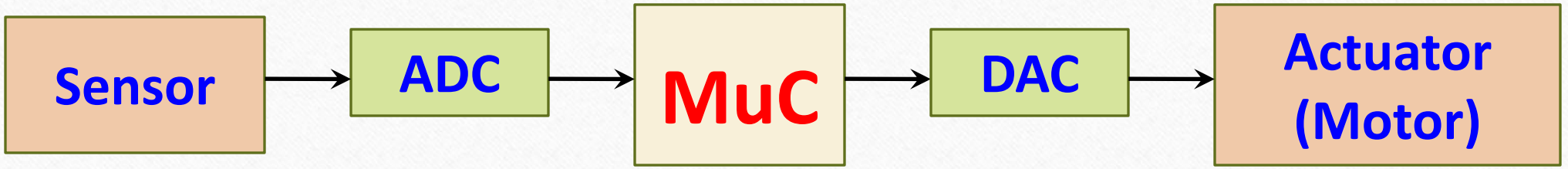
**ADC – Most of the sensors which sense quantities like temperature, pressure, velocity, light etc. produce voltage which is analog in nature. Therefore an ADC is used to convert the analog voltage to digital voltage so that the 8051 MuC can understand it. Chips like ADC0804 / 0808 / 0809 are interfaced with 8051 to get a digital signal.**



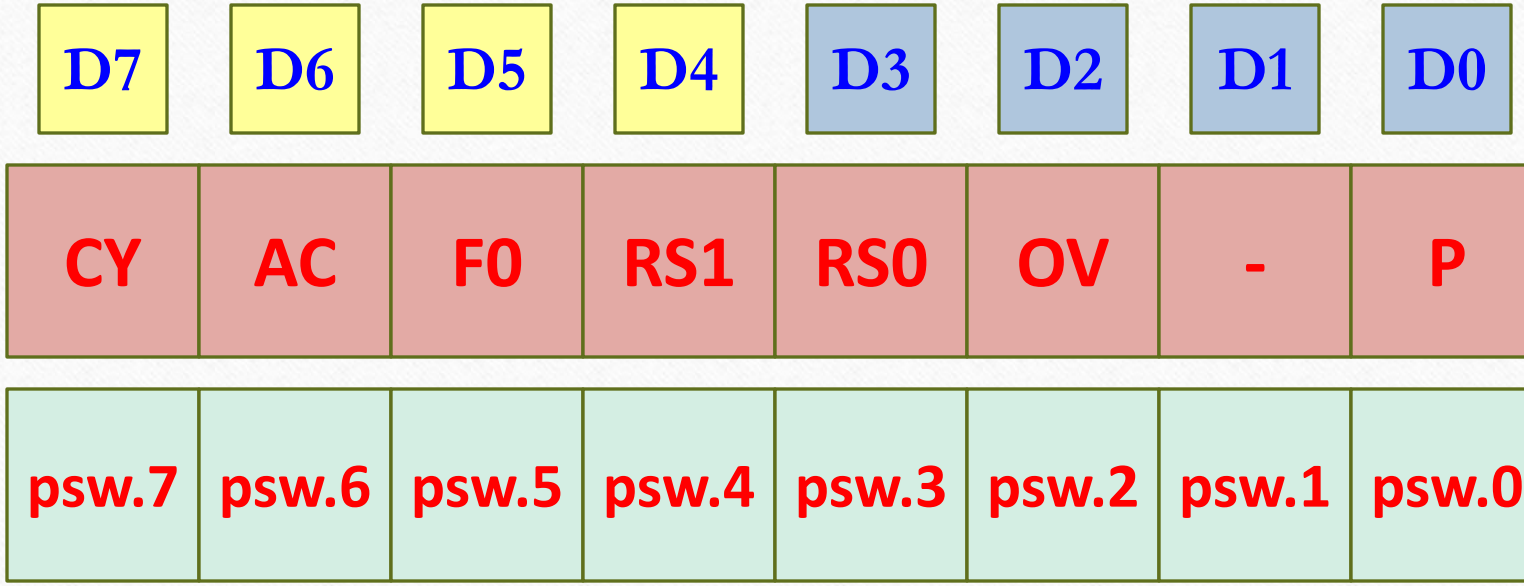
# Important terms used in a micro-controller

**DAC – The MuC generates o/p which is in digital form but the controlling system like a motor or hydraulic actuator requires analog signal as they don't accept digital data.**

**Thus, we need to used a DAC which converts digital data into equivalent analog voltage. e.g. DAC0808**



# Program Status Word – PSW 8 bit Register




**Program Status Word – PSW tells about the latest status of results in the ALU (Arithematic and Logic Unit) of the Accumulator.**

# Program Status Word – PSW 8 bit Register


**psw0 bit**

**Shows Parity of result in Accumulator A**

**( it is count no. of 1s)**

**if psw0 = 0 → even parity (0,2,4,6,8)**

**if psw0 = 1 → odd parity (1,3,5,7)**

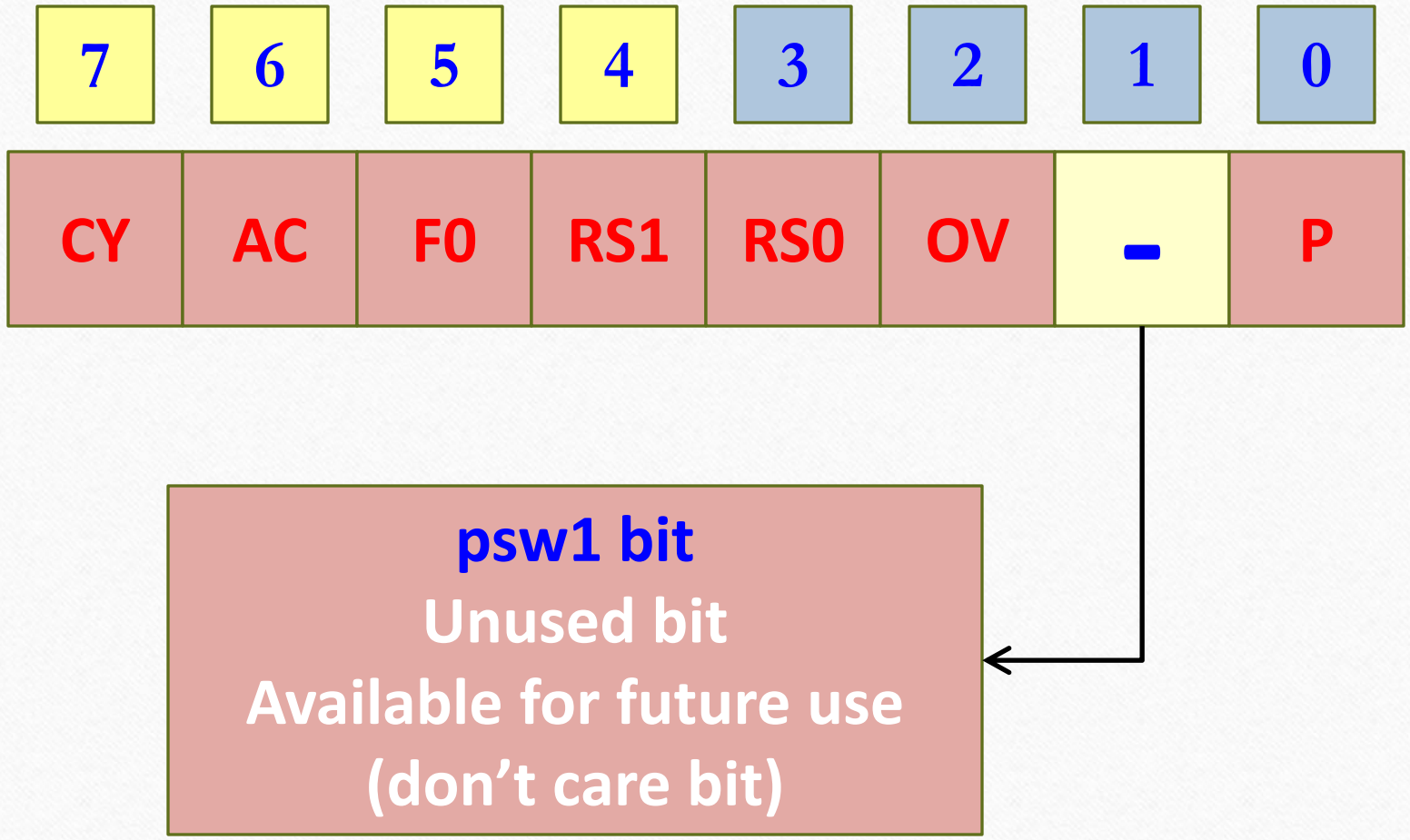
**Ex. Add**
**36 + C5**

0011 0110
+ 1100 0101
---
Accumulator has 1111 1011

**( P = 7 odd)**
**Thus, P bit will be set to 1.**

**Set means bit = 1**
**Reset means bit = 0**

# Program Status Word – PSW 8 bit Register



# Program Status Word – PSW 8 bit Register

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| CY | AC | F0 | RS1 | RS0 | OV | - | P |

OV is used to detect errors in the signed arithmetic operations.

**psw2 bit**
**Overflow bit**
**Set to 1 if overflow occurs in the Accumulator**

In case signed numbers MSB is reserved for the sign.
1 for – ve nos.
0 for + ve nos.

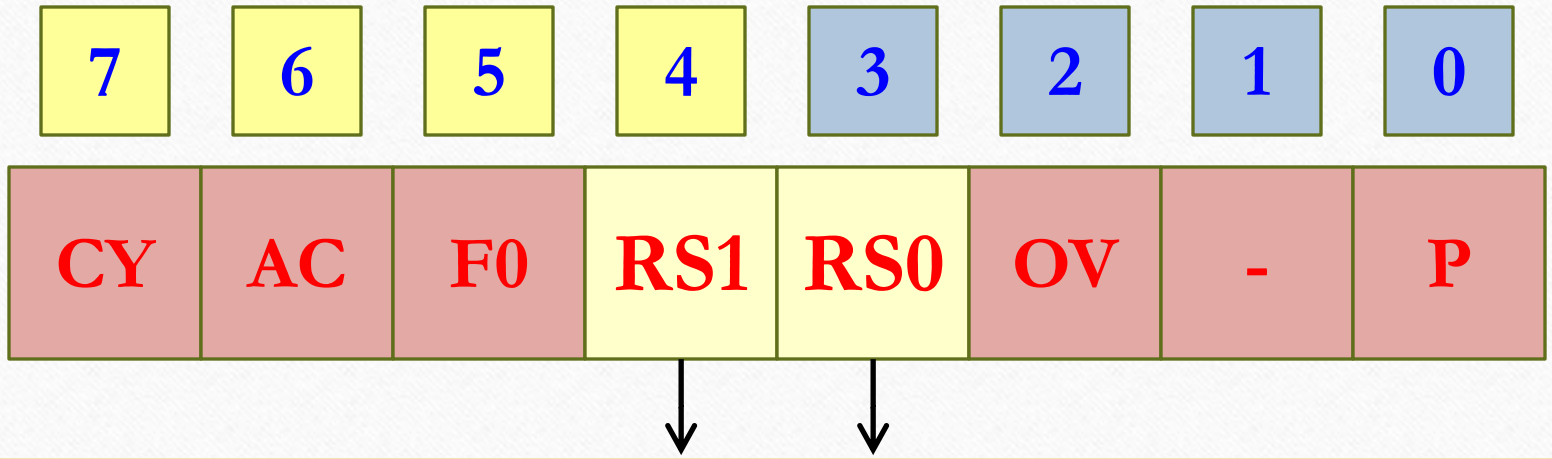
| | |
|---|---|
| 124 | 0111 1100 |
| +125 | 0111 1101 |
| -------- | ---------- |
| 249 | 1111 1001 |
| | = - 121 ?? |

If the result of an operation on signed numbers is too large, and the sign bit (MSB) is affected, then overflow is said to occur.
Overflow occurs from B06 into B07 which is MSB.
This is the sign bit. Thus, OV bit is set to 1.

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|

Accumulator

# Program Status Word – PSW 8 bit Register

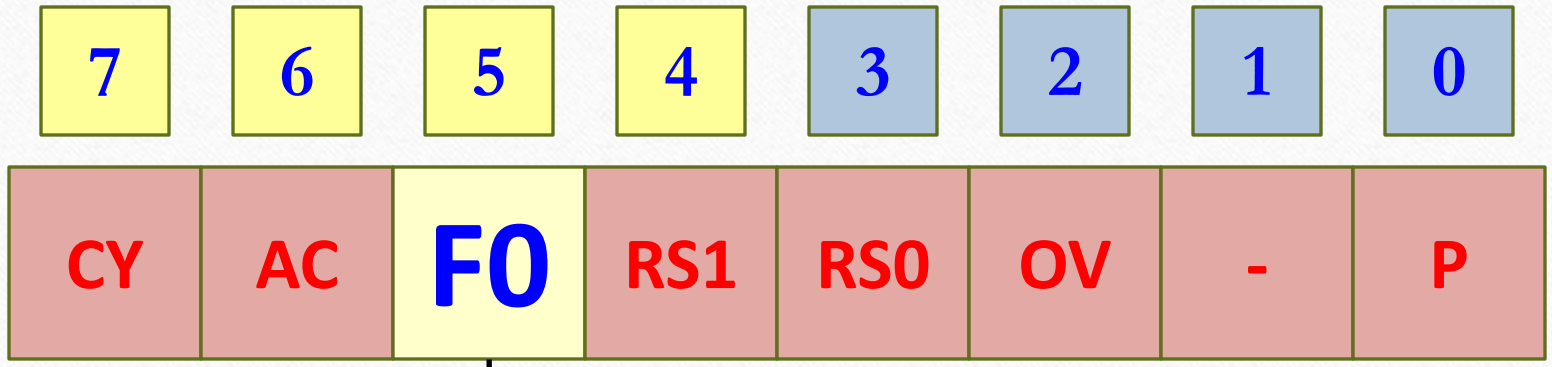



## psw3 and psw4 bit

## Two bits for Selection of Register Bank

| psw 4 | psw3 | Register Bank | Location |
|---|---|---|---|
| 0 | 0 | B0 | 00 – 07 H |
| 0 | 1 | B1 | 08 – 0F H |
| 1 | 0 | B2 | 10 – 17 H |
| 1 | 1 | B3 | 18 – 1F H |

# Program Status Word – PSW 8 bit Register




**psw5 bit**

**User defined bit**

**General purpose**

**(don’t care bit if not defined)**

# Program Status Word – PSW 8 bit Register

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| CY | AC | F0 | RS1 | RS0 | OV | - | P |

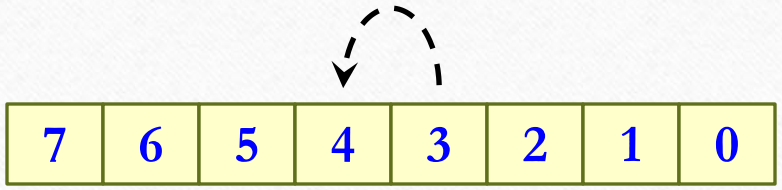
| 23+ 6E = ?? | = 91 |
|---|---|

0010 0011
+ 0110 1110
---
Accumulator has 1001 0001

**psw6 bit**

**Auxiliary Carry bit**

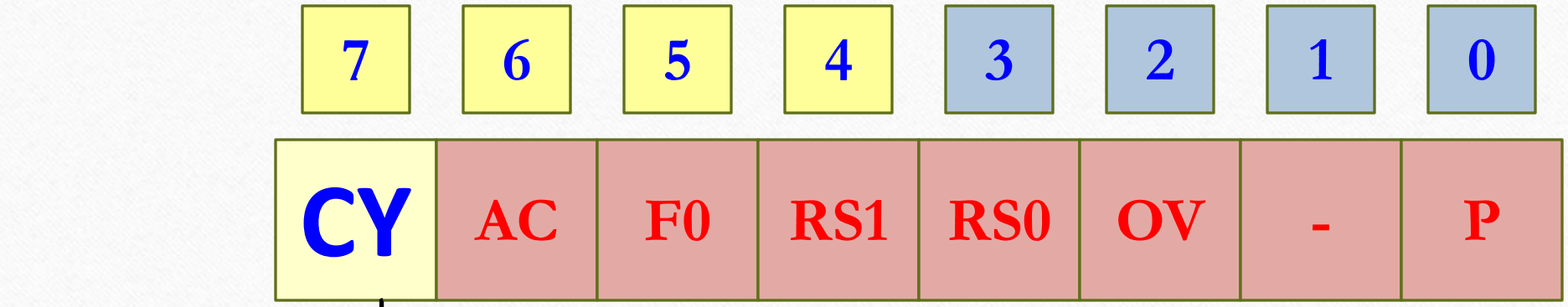
**If there occurs a carry from bit 3 to bit 4 in Accumulator, then this bit is set to 1 (lower nibble to higher nibble of A)**




Accumulator

Thus AC bit is set to 1

# Program Status Word – PSW 8 bit Register




F3+ 6E = ?? | = 161

1111 0011
+ 0110 1110
---
Accumulator has 1 0110 0001

9th bit !

CY bit is set to 1.

**psw7 bit**

**Carry Flag bit**

**This bit is set to 1 if there occurs a carry out from bit D7 in the A during calculations.**

**Program Status Word – Each bit of PSW is called as a Flag.**

- **Four of the flags are conditional flags, which means that they indicate a condition which results after an instruction is executed.**

| D7 | D6 | | | | D2 | | D0 |
|---|---|---|---|---|---|---|---|
| Carry | Aux. Carry | | | | Overflow | | Parity |

- **Two can be selected by the user (D3 and D4 – Register Banks)**
- **Two are unused (D1 and D5 – Don’t care bits)**

## Example - Find status of different bits if the PSW has B3 in it.

B 3

| 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
|---|---|---|---|---|---|---|---|
| CY | AC | F0 | RS1 | RS0 | OV | - | P |

1) P = 1 ∴ Odd parity in Accumulator

2) OV = 0 ∴ No overflow into MSB in Accumulator

3) RS1 = 1 and RS0 = 0 ∴ Register Bank RB2 is selected

4) AC = 0 ∴ No carry from lower nibble to higher nibble in Accumulator

5) CY = 1 ∴ $9^{th}$ bit is generated outside the 8 bit Accumulator

What about B1 ?

What about 93 ?

# 8051 has a total of 21 special function registers (SFRs)

**Timer Registers – 6 nos.**

TH0, TH1, TL0 and TL1 – Timer High and Timer Low Reg.

TCON – Timer Control Reg.

TMOD – Timer Mode Reg.

**Main – 2 nos.**

A – Accumulator - Math, Logical, Data manipulation

B – Extension (support Acc. for temporary storage )

# 8051 has a total of 21 special function registers (SFRs)

P0, P1, P2 and P3 – Store i/o port data – 4 nos.

PSW – Program Status Register – 1 no.

Serial Registers – 2 nos.

SCON – Serial Port Control Register

SBUF – Serial Buffer Data Register

# 8051 has a total of 21 special function registers (SFRs)

SP – Stack Pointer – for internal RAM stack – 1 no.

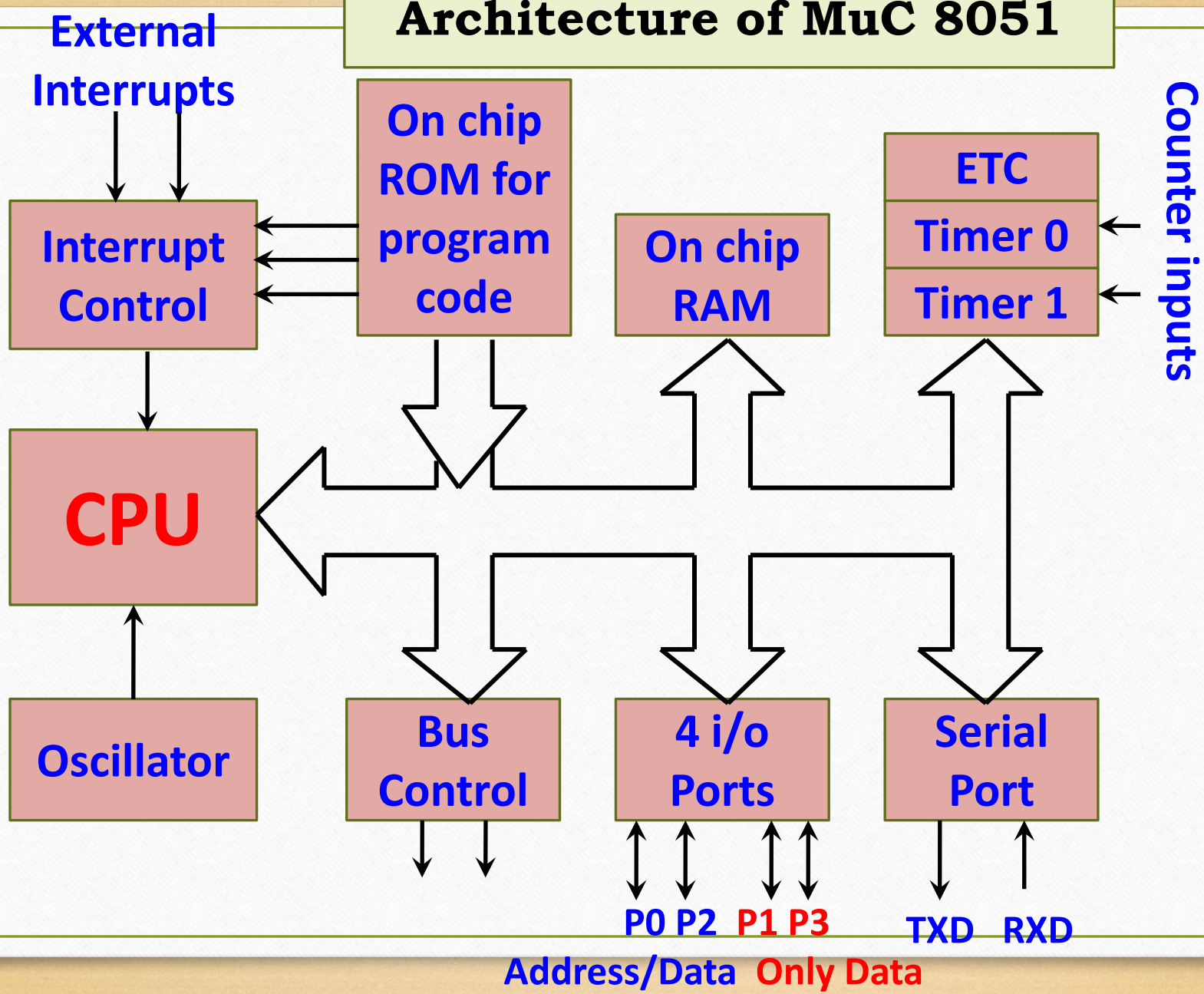
DPTR (DPH and DPL) – Data Pointer Register – 2 nos.

PCON – Power Control Register – 1 no.

IE – Interrupt Enable Control Register – 1 no.

IP – Interrupt Priority Control Register – 1 no.

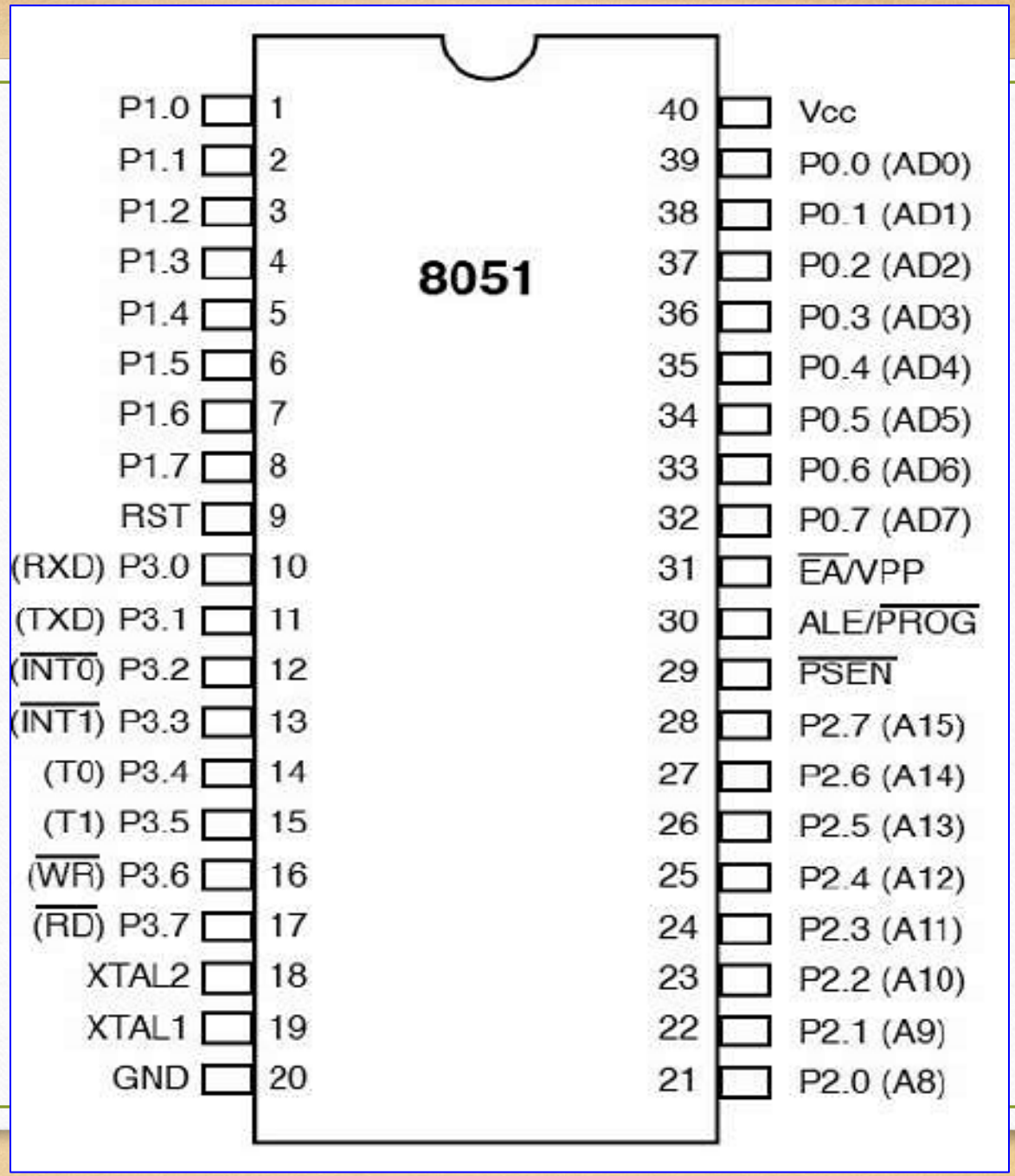
# Architecture of MuC 8051



# Pin diagram of

# Intel's 8051

# MuC



# Port Configuration of 8051

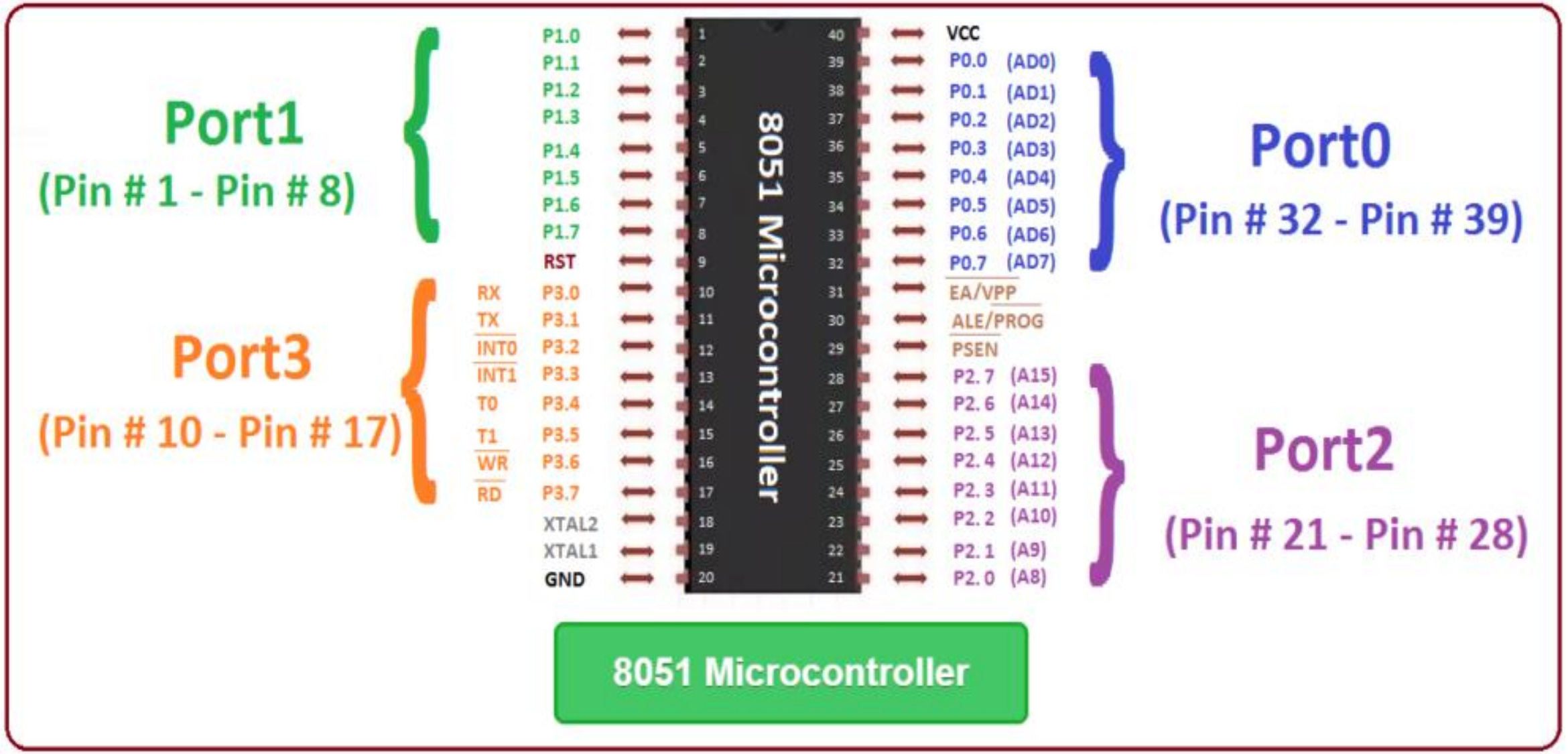
**Port 0 – Pins 32 to 39** – It serves as I/O port. Lower order address and data bus signals are multiplexed using this port.

**Port 1 – Pins 1 to 8** – Only bi-directional I/O port.

**Port 2 – Pins 21 to 28** – This port serves as I/O port. Higher order address bus signals are also multiplexed using this port.

**Port 3 – Pins 10 to 17** – This port serves as I/O port and few more functionalities like interrupts, timer input, External memory read and write, serial communication signals like RXD, TXD, etc.

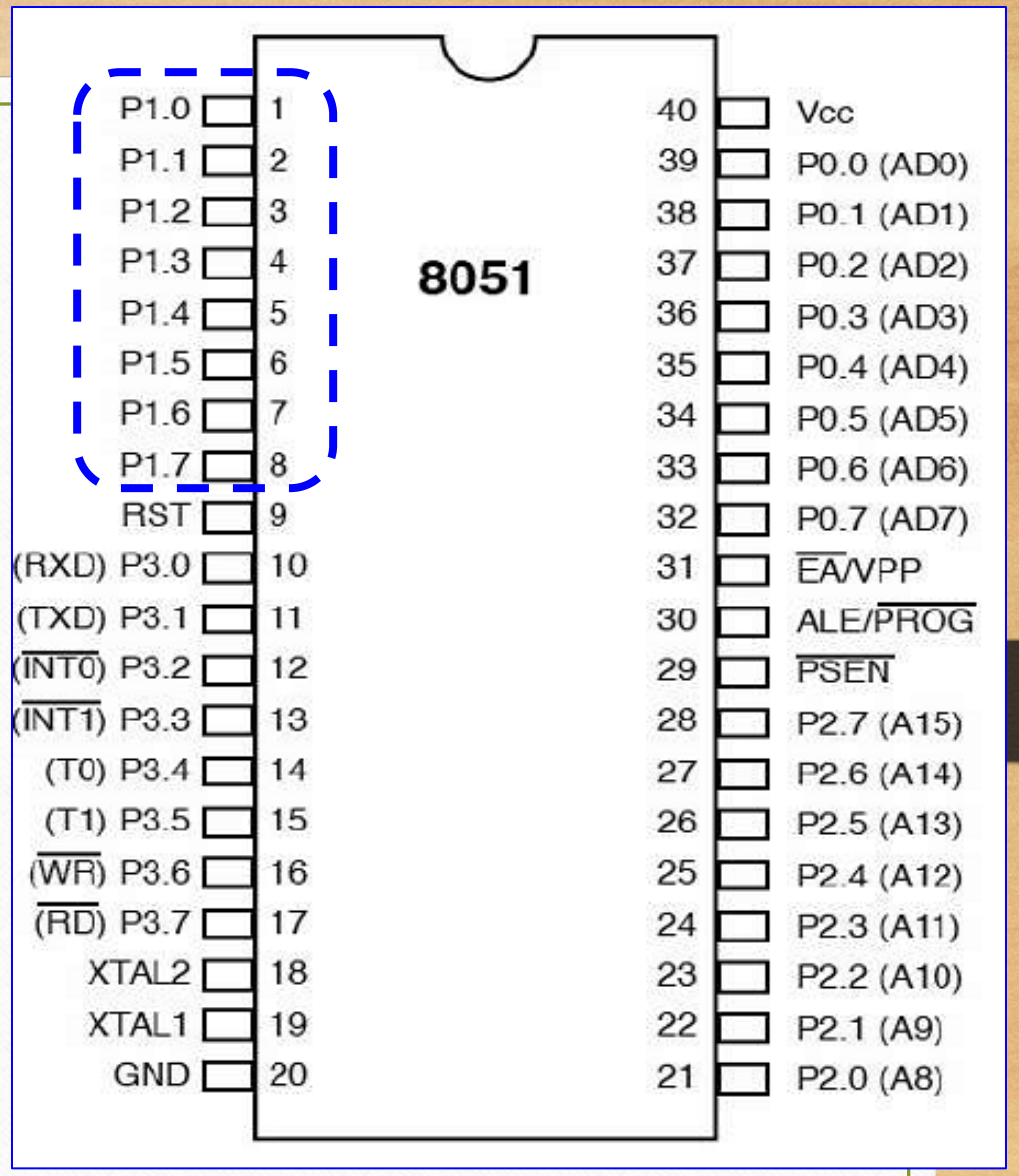
# Port Configuration of 8051




8051 Microcontroller

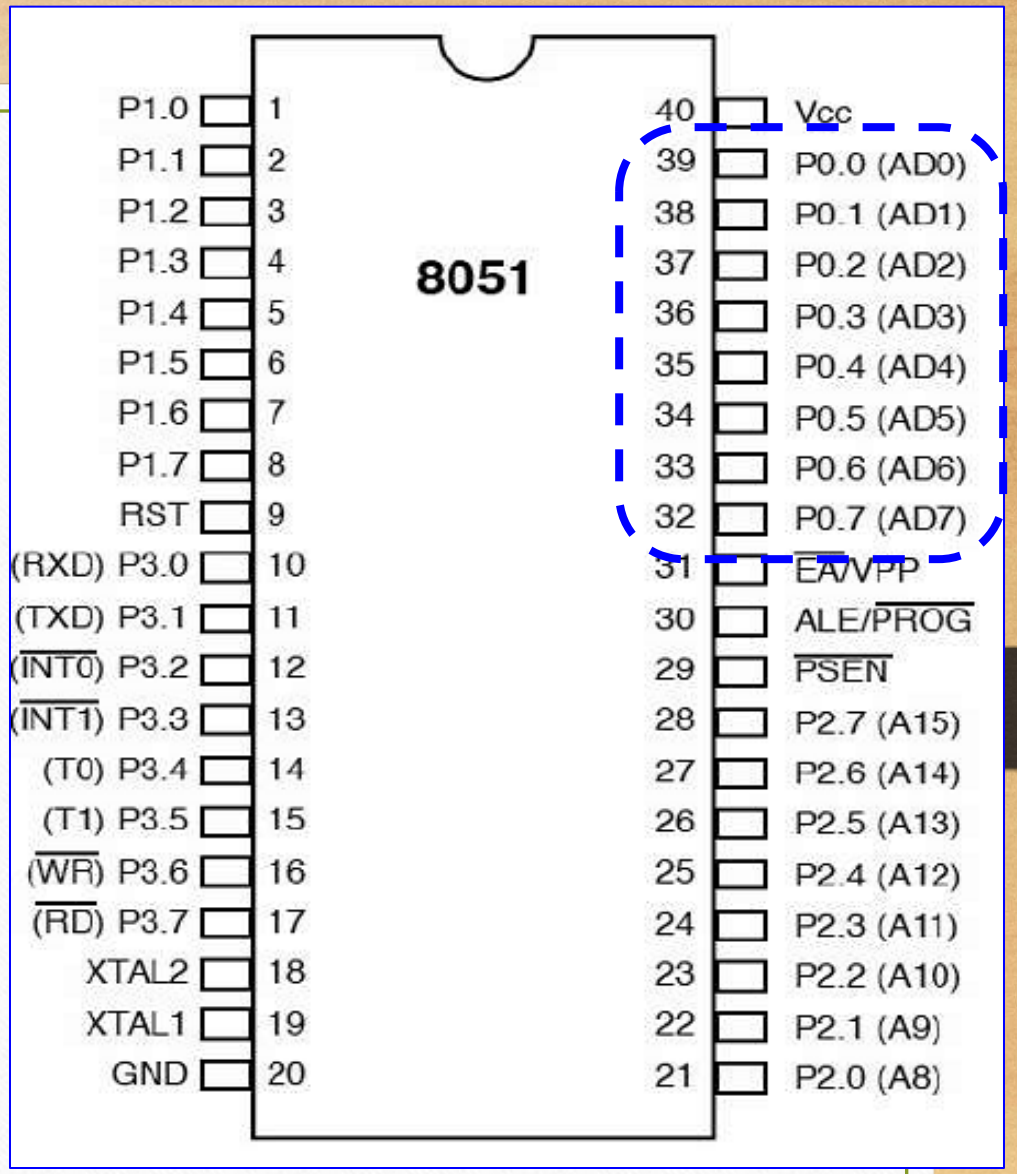
# Pin description of 8051

**Pins 1 to 8** – These pins are known as Port 1. This port doesn't serve any other functions. Only bi-directional I/O port. Default is o/p.



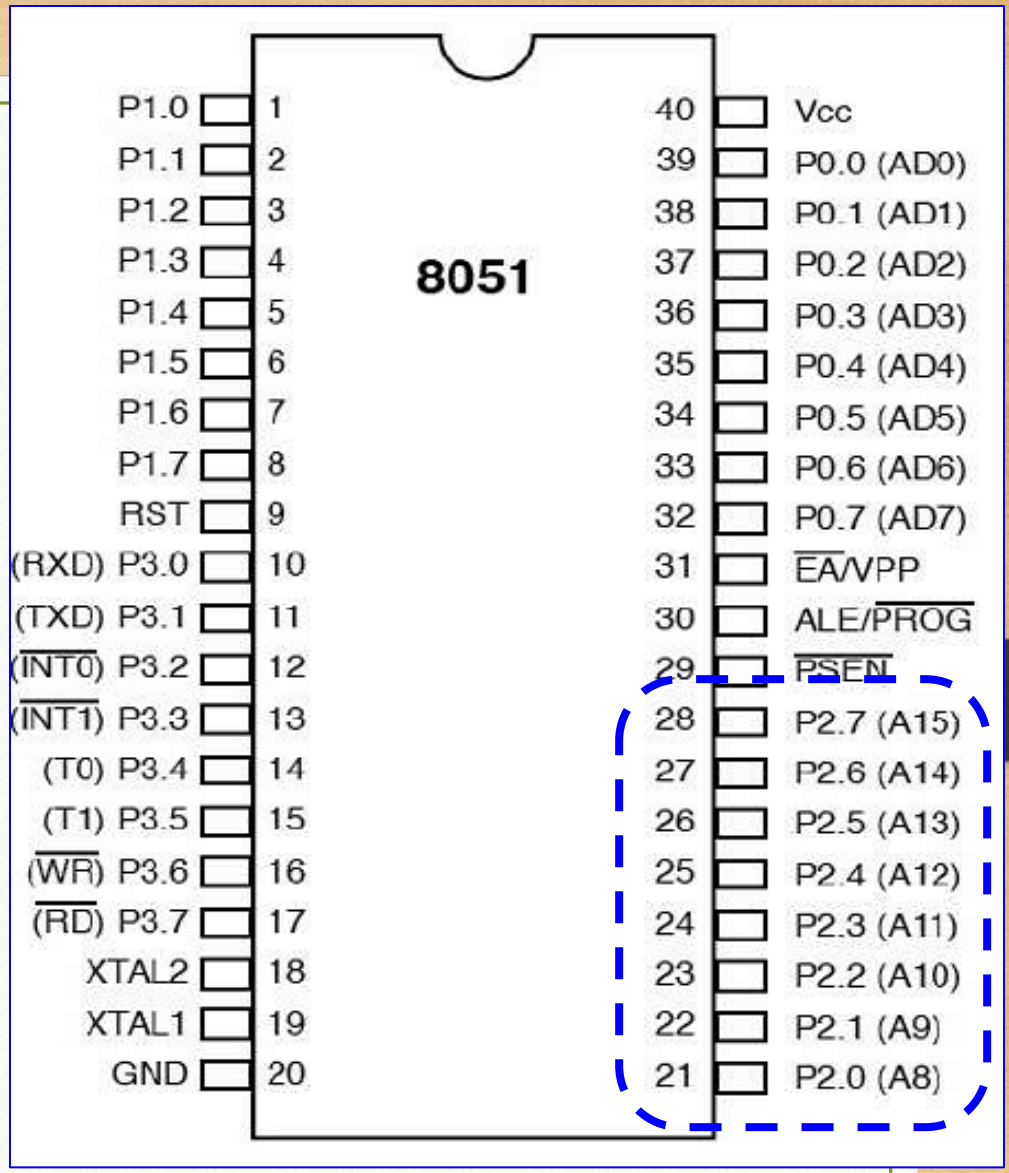
# Pin description of 8051

**Pins 32 to 39** – These pins are known as Port 0. It serves as I/O port.
When external memory is being used, it can work as Lower order address bus. Also can work as data bus signals.
Multiplexing can be done on this Port.



# Pin description of 8051

**Pins 21 to 28** – These pins are known as Port 2. This port serves as I/O port.
But when external memory is used, these pins can work as higher order address bus signals (A8 to A15) thus multiplexing is possible.



# Pin description of 8051

**Pins 10 to 17** – These pins are known as Port 3. Apart from i/o duties, this port serves some additional functions like .....

3.0 = RXD

3.1 = TXD

3.2 = $\overline{\text{INT0}}$

3.3 = $\overline{\text{INT1}}$

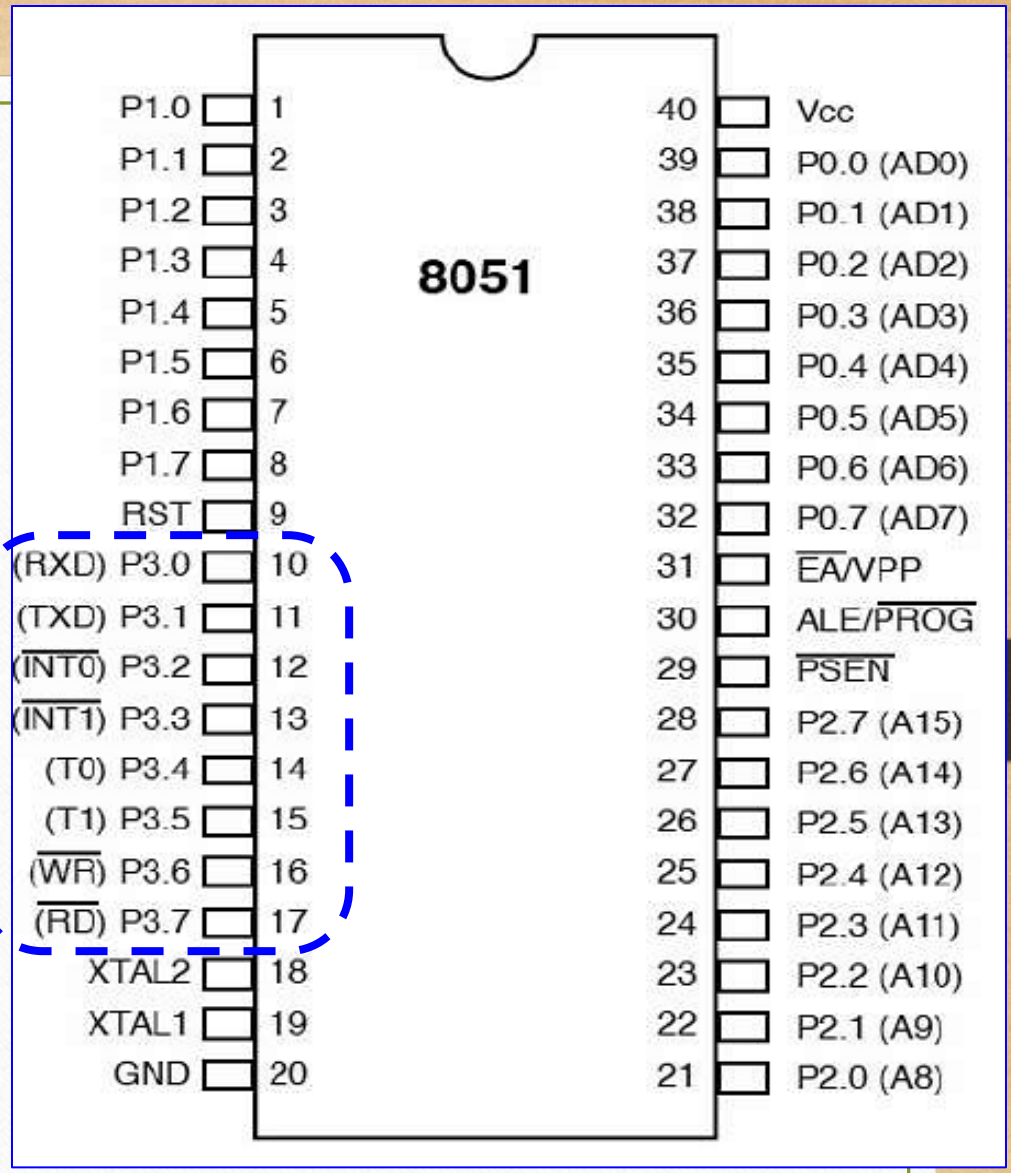
3.4 = T0

3.5 = T1

3.6 = $\overline{\text{WR}}$

3.7 = $\overline{\text{RD}}$

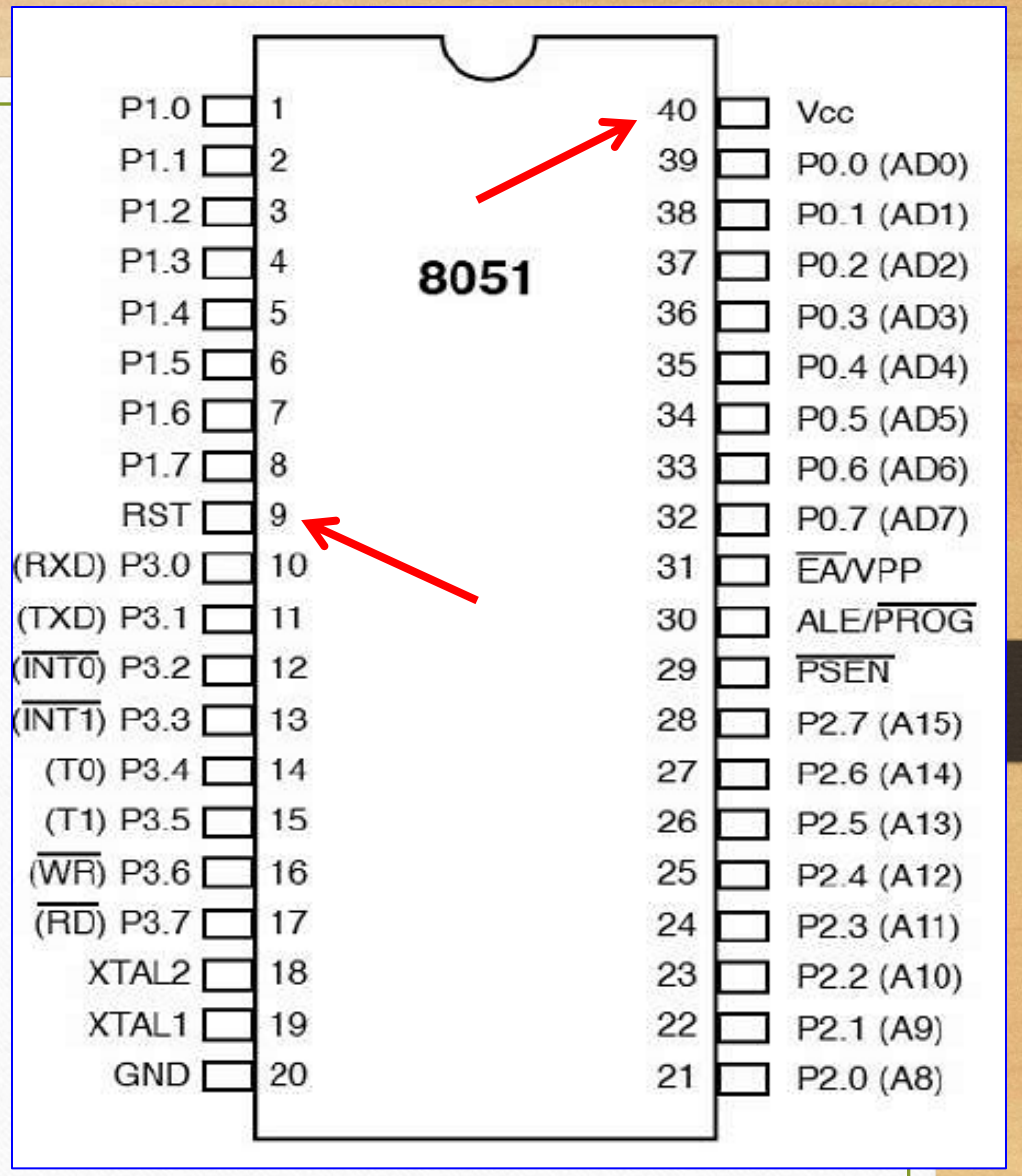
Most complicated Port !



# Pin description of 8051

**Pin 9** – It is a RESET pin, which is used to reset the microcontroller to its initial values. Just like a non maskable interrupt. Active high for 2 machine cycles, PC goes to 0000h.

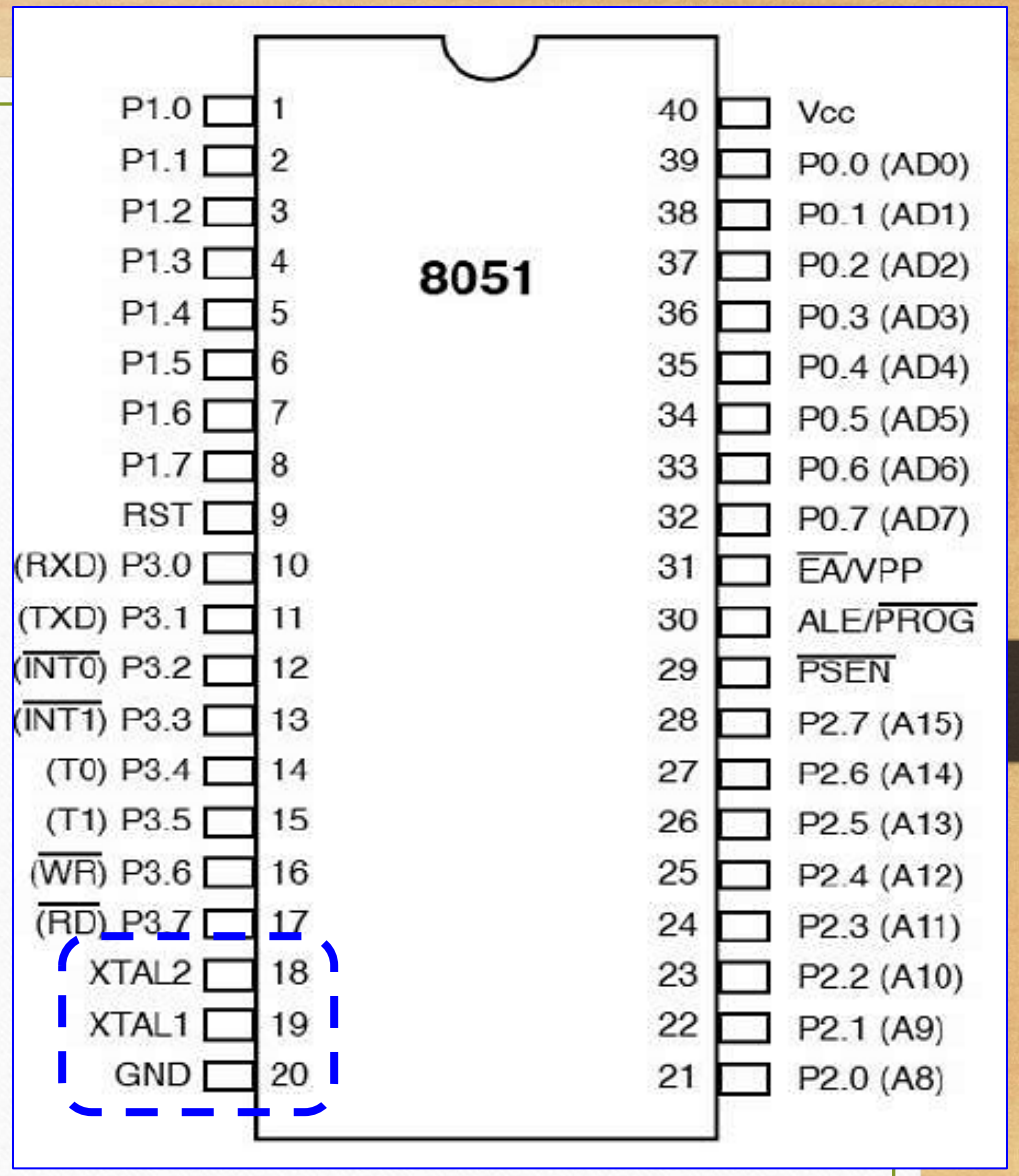
**Pin 40** – This pin is used to provide power supply to the circuit (Vcc)



# Pin description of 8051

**Pins 18 & 19** – These pins are used for interfacing an external crystal to get the system clock.

**Pin 20** – This pin provides the power supply to the circuit. (GND)

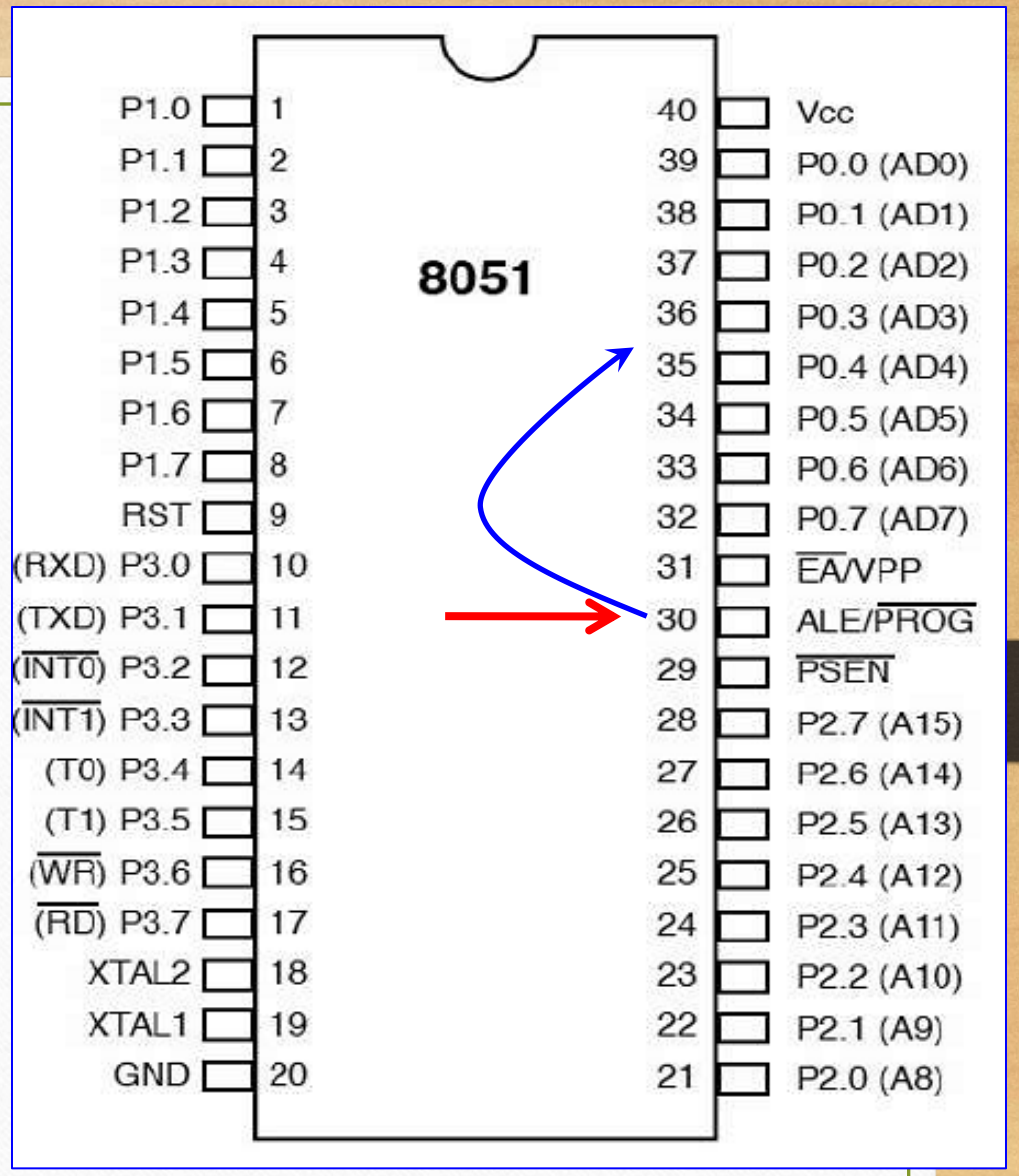


# Pin description of 8051

Pin 30 – This is ALE pin which stands for Address Latch Enable.
Active low pin.
It is used to demultiplex the address-data signal of Port0.

i.e. decide whether to deal with the address or the data.

ALE = 0 → P0 will work as data port
ALE = 1 → P0 will work as address port
(lower 8 bits)



# Pin description of 8051

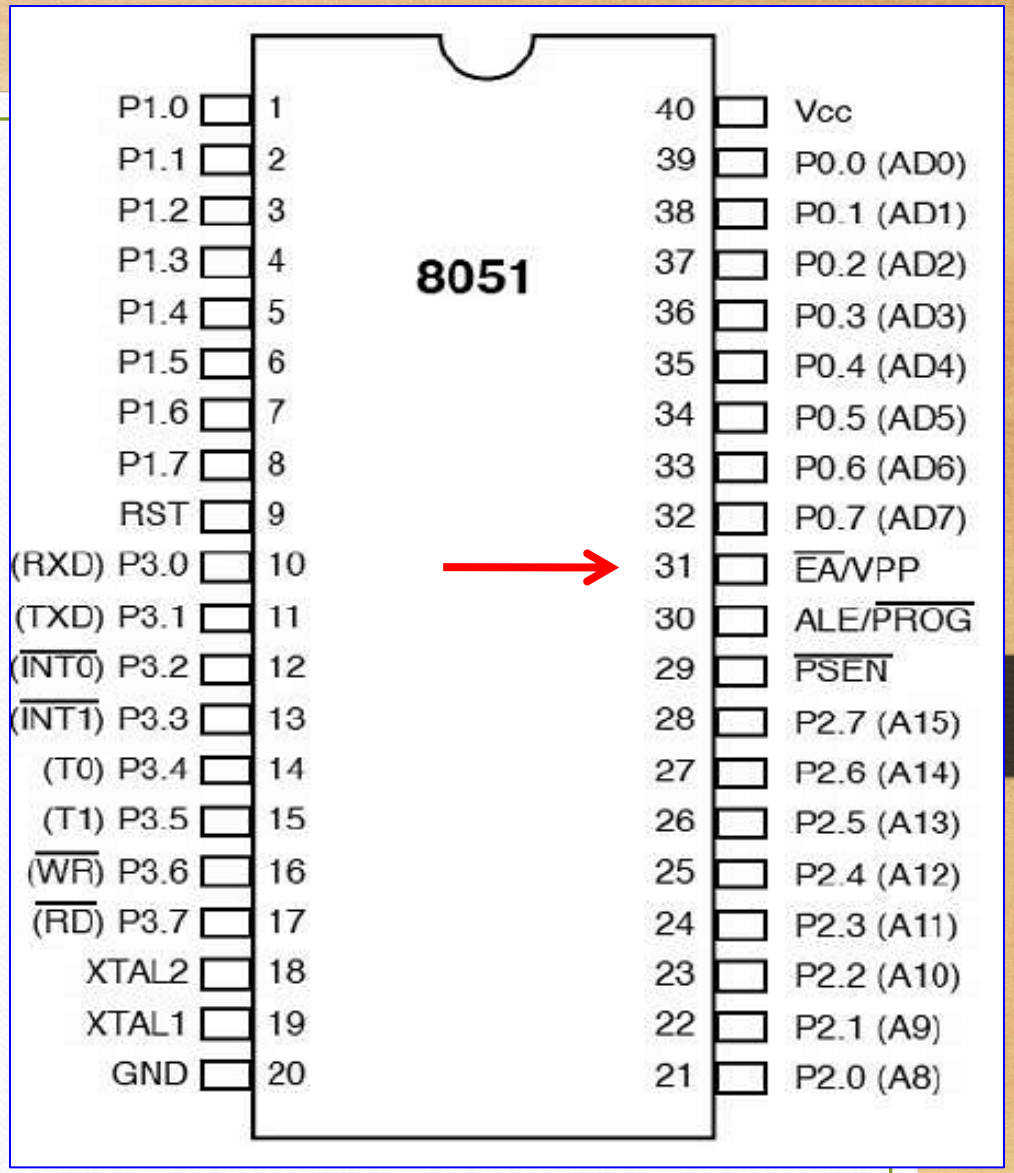
Pin 31 – 8051 has 4 KB on chip ROM and 128 Bytes of RAM.

This is EA pin which stands for External Access input.

It is used to enable/disable the external memory interfacing. Allows CPU to read data from external memories.

When externally held low (EA = 0, GND), allows access to external memory.

If EA = 1 (Vcc), only internal ROM can be accessed.

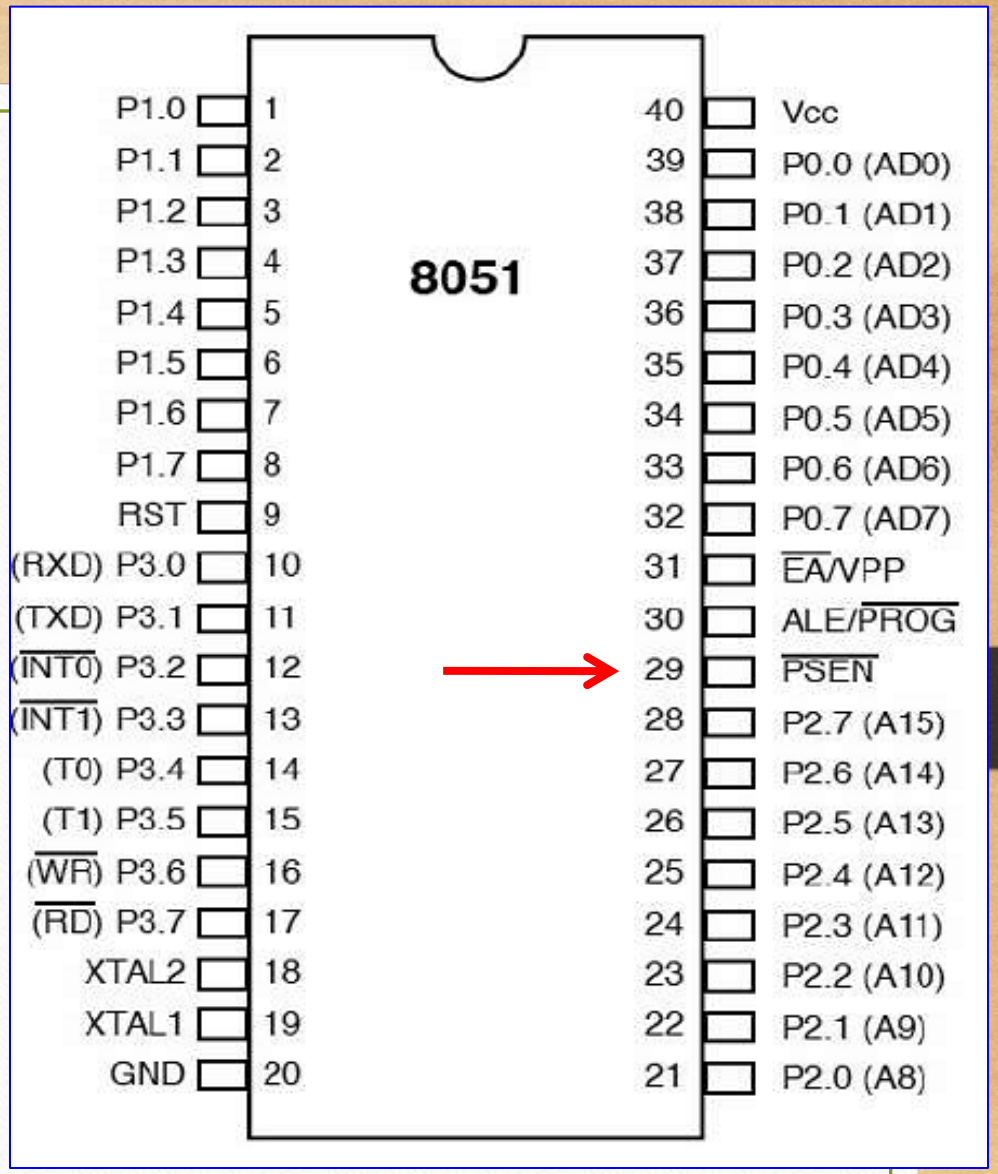


# Pin description of 8051

Pin 29 – This is PSEN pin which stands for Program Store Enable.
It is used to read a signal from the external program memory. Active low pin.

Maximum of 64 KB external ROM can be connected. (Why ?)

Pin 31 (EA) should be made low to get access to the external ROM.
When PSEN (Pin 29) = 0, the external ROM will get activated for its own access and execution.



# Port Configuration of 8051

| Port no. | Pin nos. | Basic i/o function | Additional features |
|---|---|---|---|
| 0 | 32 to 39 | Yes | Lower order address bus and data bus signals can be multiplexed |
| 1 | 1 to 8 | Yes | Nothing – only i/o |
| 2 | 21 to 28 | Yes | Higher order address bus signals can be multiplexed |
| 3 | 10 to 17 | Yes | Can be used for Interrupts, timer input, External memory read and write, serial communication signals like RXD, TXD. |