Embedded Systems
(lec_07_I/O programming)

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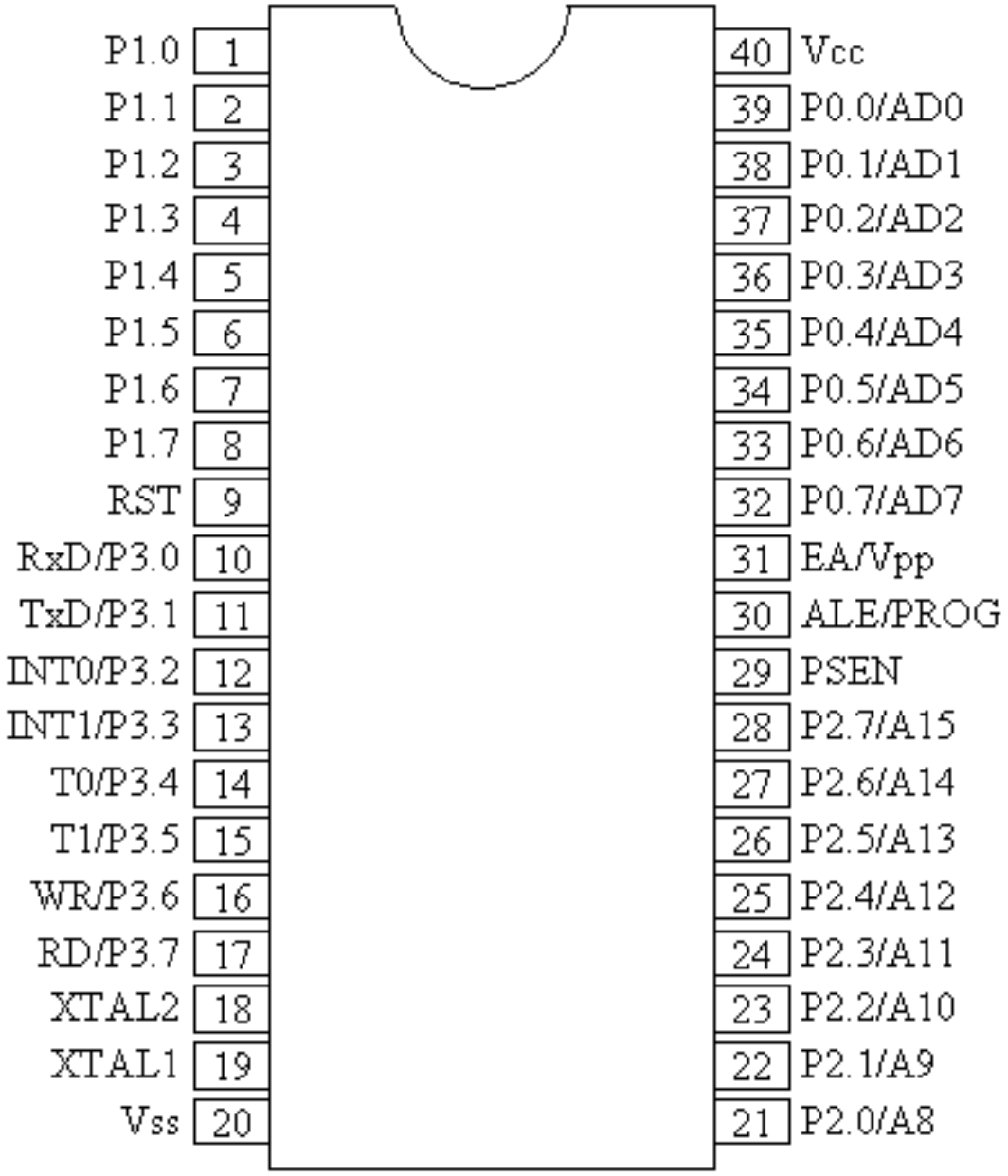
- In 8051, I/O operations are done using four ports and 40 pins. The following pin diagram shows the details of the 40 pins. I/O operation port reserves 32 pins where each port has 8 pins. The other 8 pins are designated as Vcc, GND, XTAL1, XTAL2, RST, EA (bar), ALE/PROG (bar), and PSEN (bar).

- It is a 40 Pin PDIP (Plastic Dual Inline Package).


P1.0 1
P1.1 2
P1.2 3
P1.3 4
P1.4 5
P1.5 6
P1.6 7
P1.7 8
RST 9
RxD/P3.0 10
TxD/P3.1 11
INT0/P3.2 12
INT1/P3.3 13
T0/P3.4 14
T1/P3.5 15
WR/P3.6 16
RD/P3.7 17
XTAL2 18
XTAL1 19
Vss 20
40 Vcc
39 P0.0/AD0
38 P0.1/AD1
37 P0.2/AD2
36 P0.3/AD3
35 P0.4/AD4
34 P0.5/AD5
33 P0.6/AD6
32 P0.7/AD7
31 EA/Vpp
30 ALE/PROG
29 PSEN
28 P2.7/A15
27 P2.6/A14
26 P2.5/A13
25 P2.4/A12
24 P2.3/A11
23 P2.2/A10
22 P2.1/A9
21 P2.0/A8

- **Note:** In a DIP package, you can recognize the first pin and the last pin by the cut at the middle of the IC. The first pin is on the left of this cut mark and the last pin (i.e. the 40 pin in this case) is to the right of the cut mark.

I/O Ports and their Functions

- The four ports P0, P1, P2, and P3, each use 8 pins, making them 8-bit ports. Upon RESET, all the ports are configured as inputs, ready to be used as input ports. When the first 0 is written to a port, it becomes an output. To reconfigure it as an input, a 1 must be sent to a port.

- Register are used to store information temporarily, while the information could be
  - a byte of data to be processed,
  - or an address pointing to the data to be fetched

The vast majority of 8051 register are 8-bit registers ¾ There is only one data type, 8 bits

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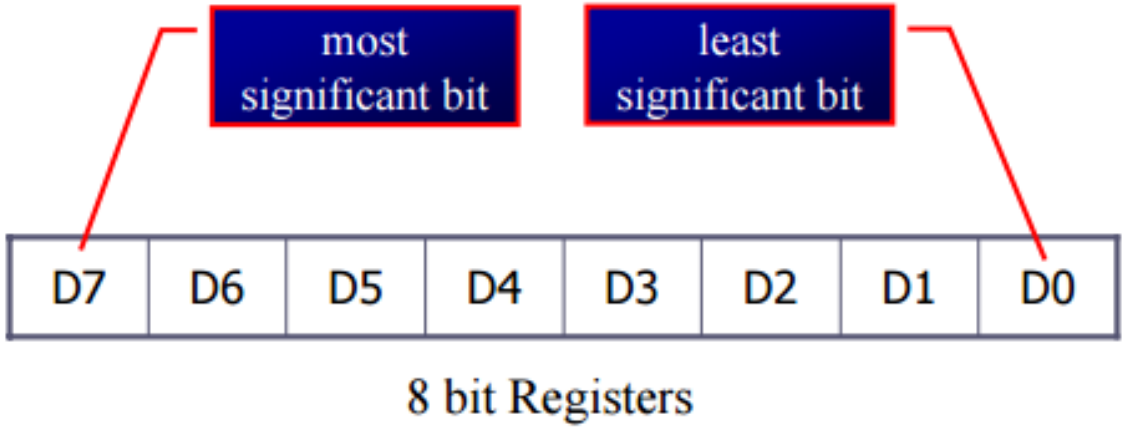
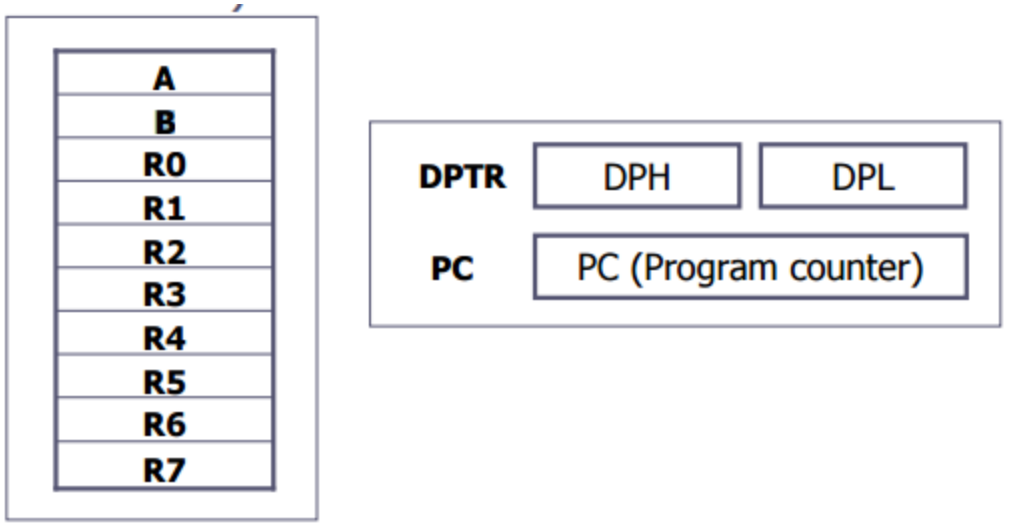
- The 8 bits of a register are shown from MSB D7 to the LSB D0
  - With an 8-bit data type, any data larger than 8 bits must be broken into 8-bit chunks be fore it is processed



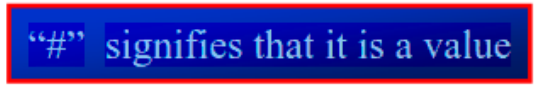
8 bit Registers

- The most widely used registers ¾
- A (Accumulator)
  - For all arithmetic and logic instructions
  - B, R0, R1, R2, R3, R4, R5, R6, R7
  - DPTR (data pointer), and PC (program counter)



MOV Instruction

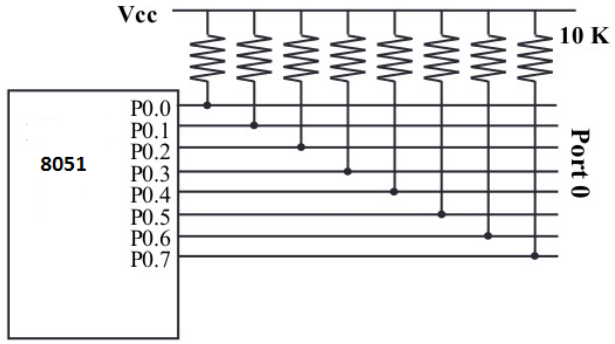
- **MOV destination, source ;copy source to dest.**
- The instruction tells the CPU to move (in reality,COPY) the source operand to the destination




```
MOV   A,#55H     ;load value 55H into reg. A
MOV   R0,A       ;copy contents of A into R0
                 ;(now A=R0=55H)
MOV   R1,A       ;copy contents of A into R1
                 ;(now A=R0=R1=55H)
MOV   R2,A       ;copy contents of A into R2
                 ;(now A=R0=R1=R2=55H)
MOV   R3,#95H    ;load value 95H into R3
                 ;(now R3=95H)
MOV   A,R3       ;copy contents of R3 into A
                 ;now A=R3=95H
```

Port 0 (Pin No 32 – Pin No 39)

- It has 8 pins (32 to 39). It can be used for input or output. Unlike P1, P2, and P3 ports, we normally connect P0 to 10K-ohm pull-up resistors to use it as an input or output port being an open drain.




```
MOV A,#0FFH        ;(comments: A=FFH(Hexadecimal  i.e. A=1111 1111)

MOV P0,A           ;(Port0 have 1's on every pin so that it works as Input)
```

- It is also designated as AD0-AD7, allowing it to be used as both address and data. In case of 8031 (i.e. ROMless Chip), when we need to access the external ROM, then P0 will be used for both Address and Data Bus.
- ALE (Pin no 31) indicates if P0 has address or data. When ALE = 0, it provides data D0-D7,
- but when ALE = 1, it has address A0-A7. In case no external memory connection is available, P0 must be connected externally to a 10K-ohm pull-up resistor.

Port 1 (Pin 1 through 8)

- It is an 8-bit port (pin 1 through 8) and can be used either as input or output. It doesn't require pull-up resistors because they are already connected internally. Upon reset, Port 1 is configured as an input port. The following code can be used to send alternating values of 55H and AAH to Port 1.

```
;Toggle all bits of continuously
MOV     A,#55
BACK:
MOV     P2,A
ACALL   DELAY
CPL      A          ;complement(invert) reg. A
SJMP    BACK
```

- If Port 1 is configured to be used as an output port, then to use it as an input port again, program it by writing 1 to all of its bits as in the following code.

```
;Toggle all bits of continuously
MOV     A ,#0FFH  ;A=FF hex
MOV     P1,A              ;Make P1 an input port
MOV         A,P1          ;get data from P1
MOV         R7,A          ;save it in Reg R7
ACALL DELAY               ;wait
MOV         A,P1          ;get another data from P1
MOV         R6,A          ;save it in R6
ACALL DELAY               ;wait
MOV         A,P1          ;get another data from P1
MOV         R5,A          ;save it in R5
```

Port 2 (Pins 21 through 28

Port 2 occupies a total of 8 pins (pins 21 through 28) and can be used for both input and output operations. Just as P1 (Port 1), P2 also doesn't require external Pull-up resistors because they are already connected internally. It must be used along with P0 to provide the 16-bit address for the external memory. So it is also designated as (A0–A7), as shown in the pin diagram. When the 8051 is connected to an external memory, it provides path for upper 8-bits of 16-bits address, and it cannot be used as I/O. Upon reset, Port 2 is configured as an input port. The following code can be used to send alternating values of 55H and AAH to port

```
;Toggle all bits of continuously
MOV     A,#55
BACK:
MOV     P2,A
ACALL   DELAY
CPL     A          ; complement(invert) reg. A
SJMP    BACK
```

If Port 2 is configured to be used as an output port, then to use it as an input port again, program it by writing 1 to all of its bits as in the following code.

```
;Get a byte from P2 and send it to P1
MOV     A,#0FFH     ;A=FF hex
MOV     P2,A        ;make P2 an input port
                    BACK:
MOV     A,P2        ;get data from P2
MOV     P1,A        ;send it to Port 1
SJMP    BACK        ;keep doing that
```

Port 3 (Pins 10 through 17)

It is also of 8 bits and can be used as Input/Output. This port provides some extremely important signals. P3.0 and P3.1 are RxD (Receiver) and TxD (Transmitter) respectively and are collectively used for Serial Communication. P3.2 and P3.3 pins are used for external interrupts.P3.4 and P3.5 are used for timers T0 and T1 respectively. P3.6 and P3.7 are Write (WR) and Read (RD)pins. These are active low pins, means they will be active when 0 is given to them and these are used to provide Read and Write operations to External ROM in 8031 based systems.

P3 Bit	Function	Pin
P3.0	RxD	10
P3.1<	TxD	11
P3.2<	Complement of INT0	12
P3.3<	INT1	13
P3.4<	T0	14
P3.5<	T1	15
P3.6<	WR	16
P3.7<	Complement of RD	17

- **Dual Role of Port 0 and Port 2**

Dual role of Port 0 – Port 0 is also designated as AD0–AD7, as it can be used for both

data and address handling. While connecting an 8051 to external memory, Port 0 can

provide both address and data. The 8051 microcontroller then multiplexes the input as

address or data in order to save pins.

Dual role of Port 2 – Besides working as I/O, Port P2 is also used to provide 16-bit

address bus for external memory along with Port 0. Port P2 is also designated as (A8–A15), while Port 0 provides the lower 8-bits via A0–A7. In other words, we can say that when an 8051 is connected to an external memory (ROM) which can be maximum up to 64KB and this is possible by 16 bit address bus because we know 216 = 64KB. Port2 isused for the upper 8-bit of the 16 bits address, and it cannot be used for I/O and this is the way any Program code of external ROM is addressed.