I/O Ports in AVR

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Topics

- AVR pin out
- The structure of I/O pins
- I/O programming
- Bit manipulating

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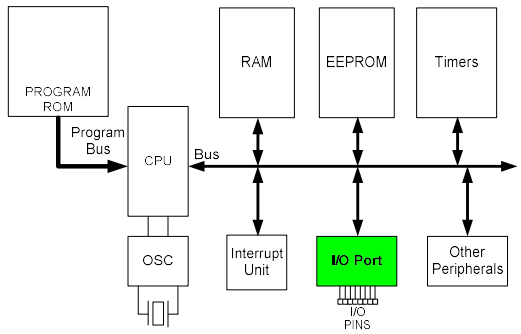
I/O unit in AVR



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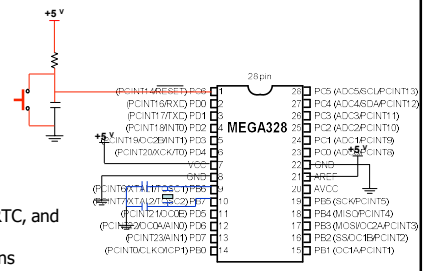
ATmega328 pinout

1. Vital Pins:
   1. Power
      - VCC
      - Ground
   2. Crystal
      - XTAL1
      - XTAL2
   3. Reset
2. I/O pins
   - PORTB, PORTC, and PORTD
3. Internal ADC pins
   - AREF, AVCC, ADCn



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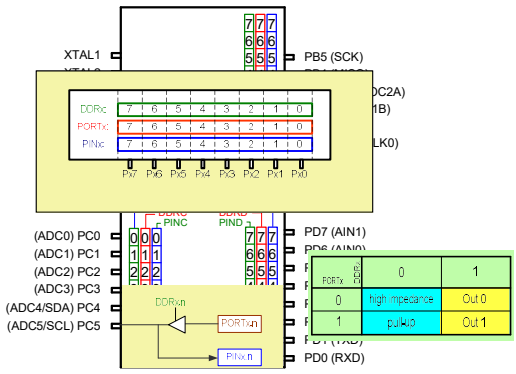
The structure of I/O pins



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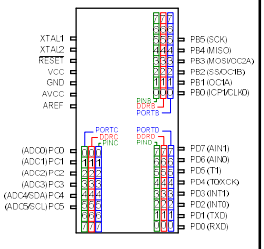
Example 1

- Write a program that makes all the pins of PORTB one.

DDRB: 1 1 1 1 1 1 1 1

PORTB: 1 1 1 1 1 1 1 1

```
LDI   R20,0xFF  ;R20 = 11111111 (binary)
OUT   PORTB,R20 ;PORTB = R20
OUT   DDRB,R20  ;DDRB = R20
```



PORTx \ DDRx	0	1
0	high impedance	Out0
1	pull-up	Out1

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Example 2

- The following code will toggle all 8 bits of Port B forever with some time delay between "on" and "off" states:

```
    LDI   R16,0xFF    ;R16 = 0xFF = 0b11111111
    OUT   DDRB,R16    ;make Port B an output port (1111 1111)
L1: LDI   R16,0x55    ;R16 = 0x55 = 0b01010101
    OUT   PORTB,R16   ;put 0x55 on port B pins
    CALL  DELAY
    LDI   R16,0xAA    ;R16 = 0xAA = 0b10101010
    OUT   PORTB,R16   ;put 0xAA on port B pins
    CALL DELAY
    RJMP L1
```


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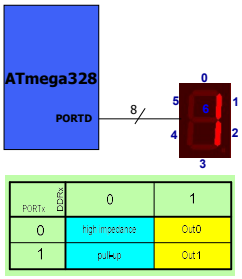
Example 3

- A 7-segment is connected to PORTD. Display 1 on the 7-segment.

DDRD: 1 1 1 1 1 1 1 1
PORTD: 0 0 0 0 0 1 1 0

```
    LDI  R20,0x06  ;R20 = 00000110 (binary)
    OUT  PORTD,R20 ;PORTD = R20
    LDI  R20,0xFF  ;R20 = 11111111 (binary)
    OUT  DDRD,R20  ;DDRD = R20
L1: RJMP L1
```



PORTx \ DDRx	0	1
0	high impedance	Out0
1	pull-up	Out1

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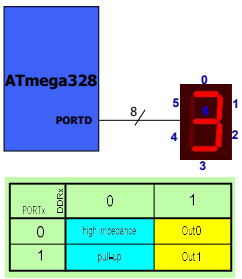
Example 4

- A 7-segment is connected to PORTD. Display 3 on the 7-segment.

DDRD: 1 1 1 1 1 1 1 1
PORTD: 0 1 0 0 1 1 1 1

```
    LDI  R20,0x4F  ;R20 = 01001111 (binary)
    OUT  PORTD,R20 ;PORTD = R20
    LDI  R20,0xFF  ;R20 = 11111111 (binary)
    OUT  DDRD,R20  ;DDRD = R20
L1: RJMP L1
```



PORTx \ DDRx	0	1
0	high impedance	Out0
1	pull-up	Out1

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Example 5: Input

- The following code gets the data present at the pins of port C and sends it to port B indefinitely, after adding the value 5 to it:

```
        LDI     R16,0x00        ;R16 = 00000000 (binary)
        OUT     DDRC,R16        ;make Port C an input port
        LDI     R16,0xFF        ;R16 = 11111111 (binary)
        OUT     DDRB,R16        ;make Port B an output port(1 for Out)
L2:     IN      R16,PINC        ;read data from Port C and put in R16
        LDI     R17,5
        ADD     R16,R17         ;add 5 to it
        OUT     PORTB,R16       ;send it to Port B
        RJMP    L2              ;jump L2
```

PORTx \ DDRx	0	1
0	high impedance	Out 0
1	pull-up	Out 1

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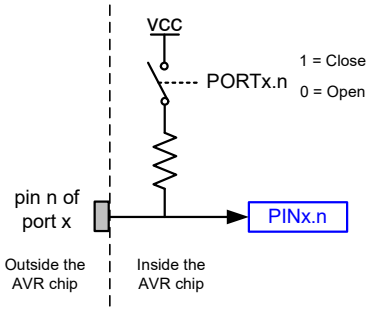
Pull-up resistor



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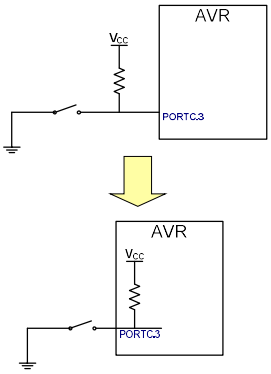
Example



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I/O bit manipulation programming

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SBI and CBI instructions

- SBI (Set Bit in IO register)
  - SBI ioReg, bit ;ioReg.bit = 1
  - Examples:
    - SBI PORTD,0 ;PORTD.0 = 1
    - SBI DDRC,5 ;DDRC.5 = 1
- CBI (Clear Bit in IO register)
  - CBI ioReg, bit ;ioReg.bit = 0
  - Examples:
    - CBI PORTD,0 ;PORTD.0 = 0
    - CBI DDRC,5 ;DDRC.5 = 0

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Example

- Write a program that toggles PORTB.4 continuously.

```
    SBI  DDRB,4
L1: SBI  PORTB,4
    CBI  PORTB,4
    RJMP L1
```

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Example

- An LED is connected to each pin of Port D. Write a program to turn on each LED from pin D0 to pin D7. Call a delay module before turning on the next LED.

```
        LDI     R20, 0xFF
        OUT     DDRD, R20       ;make PORTD an output port
        SBI     PORTD,0         ;set bit PD0
        CALL    DELAY           ;delay before next one
        SBI     PORTD,1         ;turn on PD1
        CALL    DELAY           ;delay before next one
        SBI     PORTD,2         ;turn on PD2
        CALL    DELAY
        SBI     PORTD,3
        CALL    DELAY
        SBI     PORTD,4
        CALL    DELAY
        SBI     PORTD,5
        CALL    DELAY
        SBI     PORTD,6
        CALL    DELAY
        SBI     PORTD,7
        CALL    DELAY
```


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SBIC and SBIS

- SBIC (Skip if Bit in IO register Cleared)
  - SBIC ioReg, bit ; if (ioReg.bit = 0) skip next instruction
  - Example:

```
SBIC  PORTD,0  ;skip next instruction if PORTD.0=0
INC   R20
LDI   R19,0x23
```

- SBIS (Skip if Bit in IO register Set)
  - SBIS ioReg, bit ; if (ioReg.bit = 1) skip next instruction
  - Example:

```
SBIS  PORTD,0  ;skip next instruction if PORTD.0=1
INC   R20
LDI   R19,0x23
```


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Example

- Write a program to perform the following:
- (a) Keep monitoring the PB2 bit until it becomes HIGH;
- (b) When PB2 becomes HIGH, write value $45 to Port C, and also send a HIGH-to-LOW pulse to PD3.

```
        CBI   DDRB, 2       ;make PB2 an input
        SBI   PORTB,2
        LDI   R16, 0xFF
        OUT   DDRC, R16     ;make Port C an output port
        SBI   DDRD, 3       ;make PD3 an output
AGAIN:  SBIS  PINB, 2       ;Skip if Bit PB2 is HIGH
        RJMP  AGAIN         ;keep checking if LOW
        LDI   R16, 0x45
        OUT   PORTC, R16    ;write 0x45 to port C
        SBI   PORTD, 3      ;set bit PD3 (H-to-L)
        CBI   PORTD, 3      ;clear bit PD3
HERE:   RJMP  HERE
```


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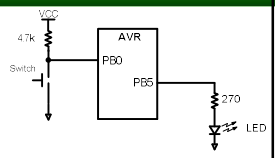
Example

- A switch is connected to pin PB0 and an LED to pin PB5. Write a program to get the status of SW and send it to the LED.




```
        CBI   DDRB,0        ;make PB0 an input
        SBI   DDRB,5        ;make PB5 an output
AGAIN:  SBIC  PINB,0        ;skip next if PB0 is clear
        RJMP  OVER          ;(JMP is OK too)
        CBI   PORTB,5
        RJMP  AGAIN         ;we can use JMP too
OVER:   SBI   PORTB,5
        RJMP  AGAIN         ;we can use JMP too
```

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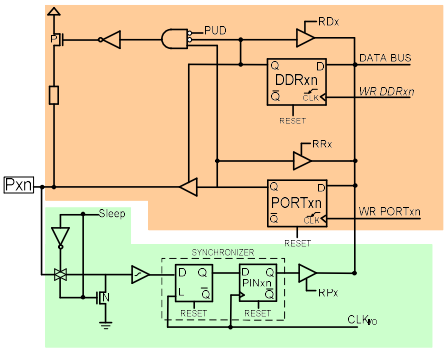
The structure of I/O pins



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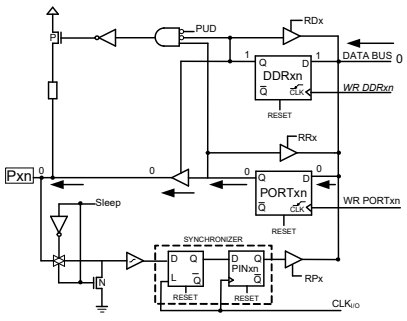
Out 0



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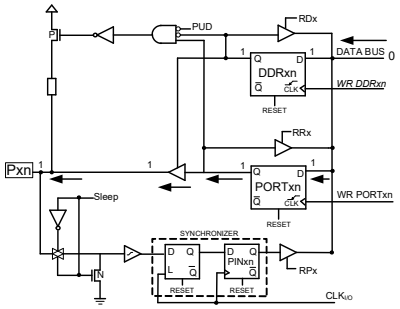
Out 1



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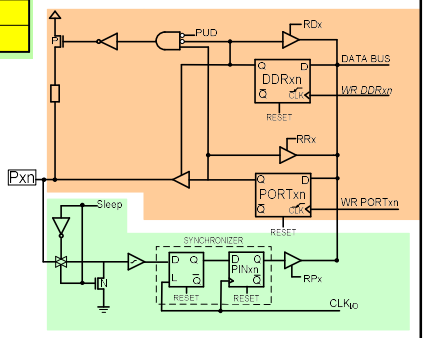
The structure of I/O pins

DDRx / PORTx	0	1
0	high impedance	Out0
1	pull-up	Out1



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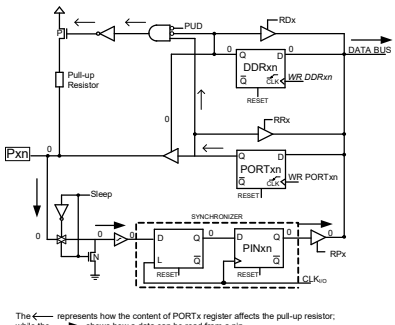
Input (Tri-state vs. pull up)



The ⟵ represents how the content of PORTx register affects the pull-up resistor; while the ⟶ shows how a data can be read from a pin

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