Basic I/O Interfacing on AlphaBot

Embedded Real-Time Systems (ERTS) Lab
Indian Institute of Technology, Bombay

Agenda for Discussion

1. AlphaBot Introduction
   - AlphaBot
2. Input-Output Ports in ATmega 328p
   - Overview of Ports
   - Ports in ATmega 328p
   - Accessing Ports
   - Examples
3. Write Your First Embedded C Program
   - LED Interfacing
   - Need for masking
   - Masking Operators

AlphaBot

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1. Mobile robot development platform

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2. Plug-and-play modules like line tracking, obstacle avoidance, speed measuring, etc.

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3. L298P motor driver with diode protection circuit
4. TLC1543 AD acquisition chip

AlphaBot Compatible Boards

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Compatible with Arduino/Raspberry Pi

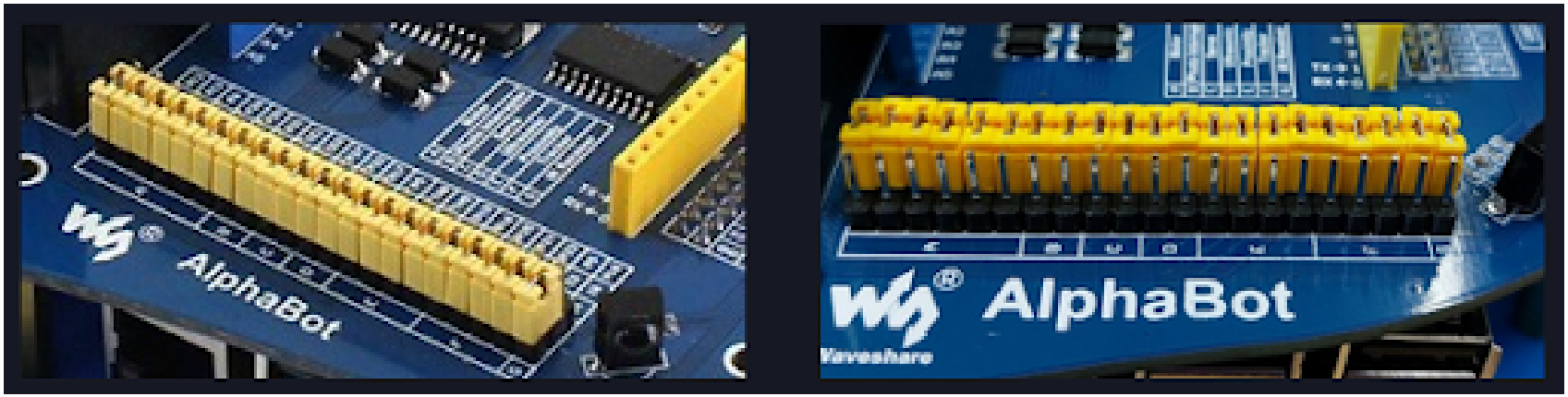

Figure: (a) Robot with jumpers to select Arduino and (b) Robot with jumpers to select Raspberry Pi

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  2. Output Device:

     Example: Buzzer, LCD, Motors, LED, etc...

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     Port C;
- All Port pins can be individually configured as Input/Output.

Arduino - ATmega 328p pin mapping

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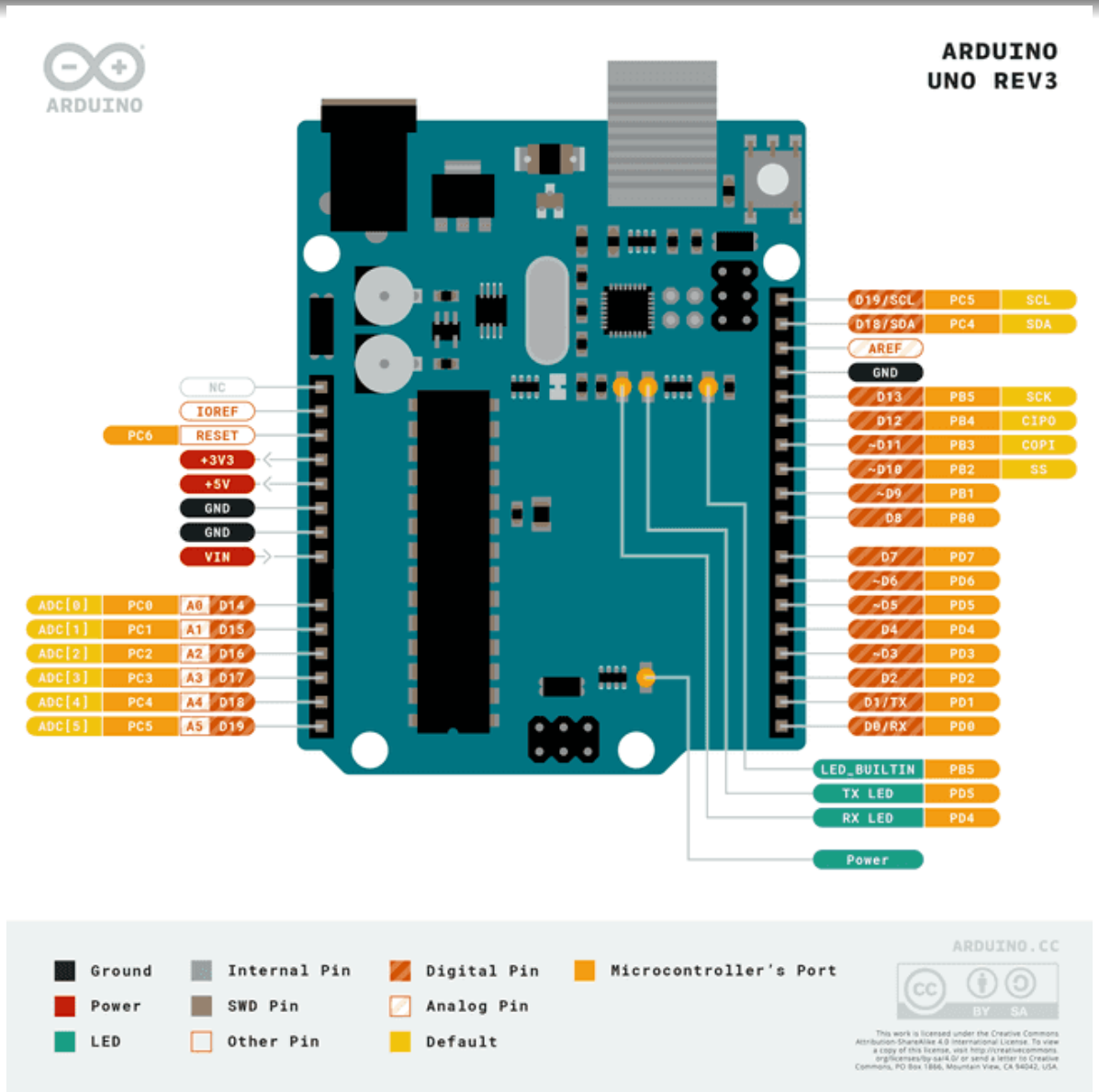

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x = PINB

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DDRB = 0xFF

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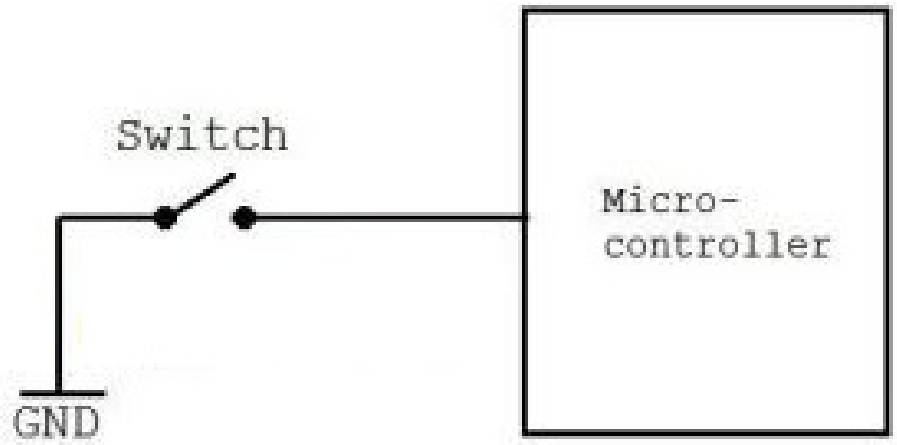

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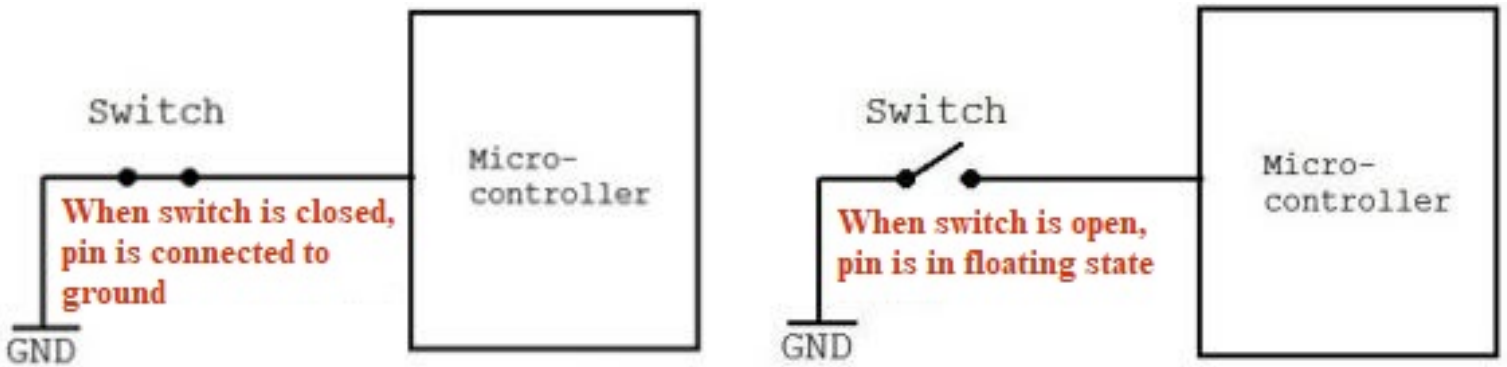

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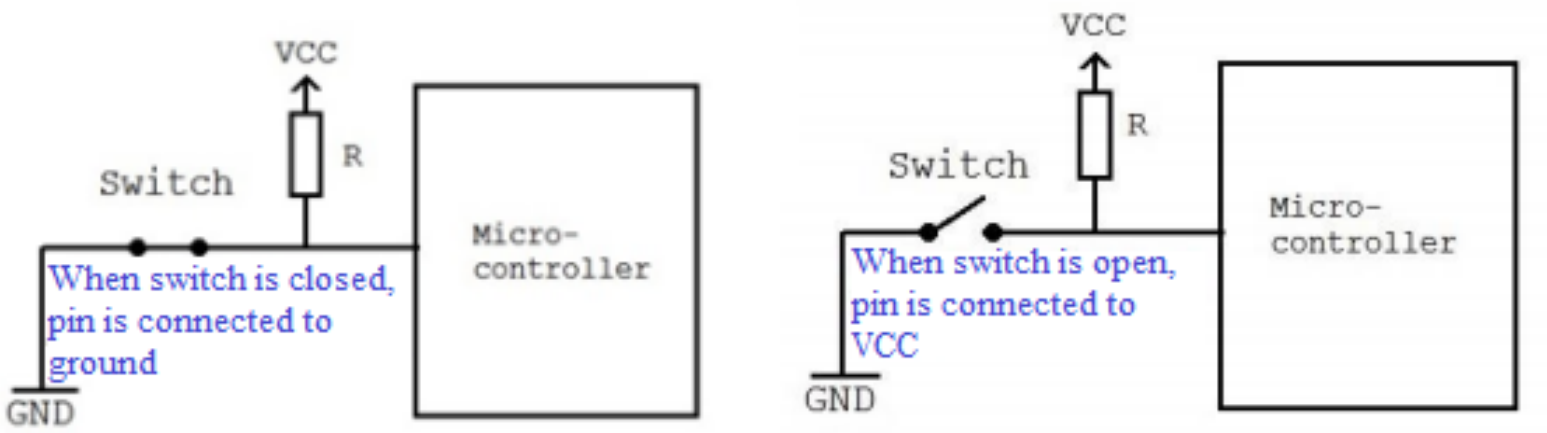

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0	0	0	0	0	0	0	0

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PORTB = 0xFF

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Pull-Up is activated for all Pins of PortB.

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D7	D6	D5	D4	D3	D2	D1	D0
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DDRD = 0xFF

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2. Step 2: Put data on the Port D

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D7	D6	D5	D4	D3	D2	D1	D0
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PORTD =

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PORTD =

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DDRD = 0xFF

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PORTD =

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PORTD = 0xD5

Examples (Cont..)

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Examples

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- Example: Connect LEDs to lower nibble and Switches to upper nibble of PortB. Turn ON alternate LEDs (0 and 2) and activate pull up for all Switches. Read data using PIN register. What will be the content of PINB register, if only Switch at pin 5 is pressed?

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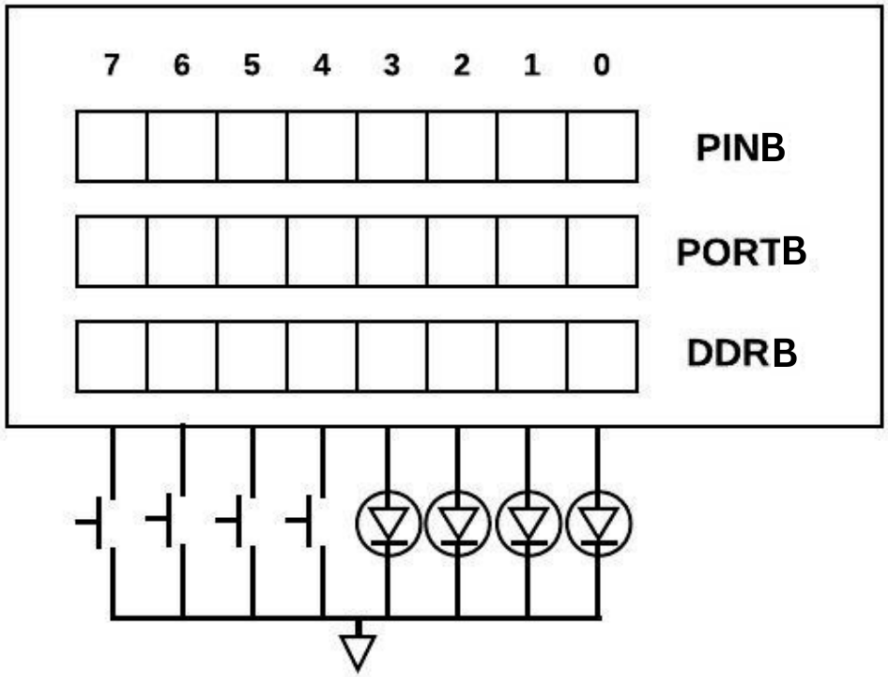

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- Step 1: Make upper nibble as Input and lower nibble as Output.

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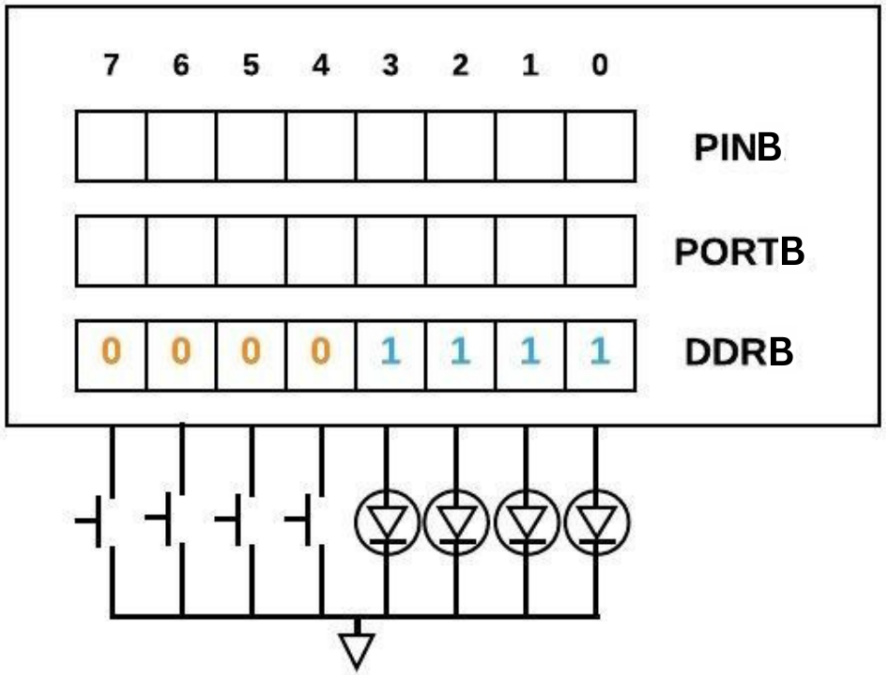

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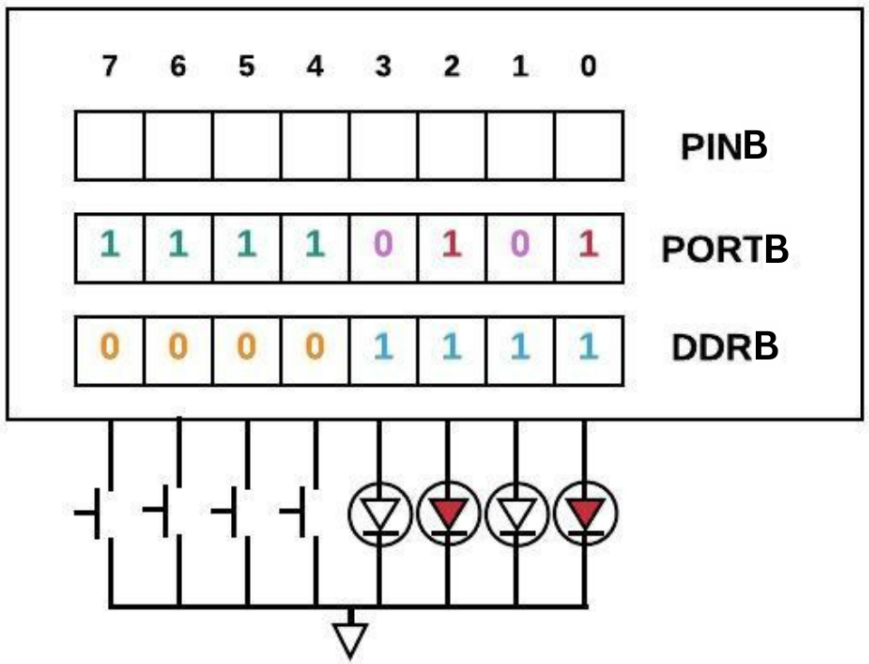

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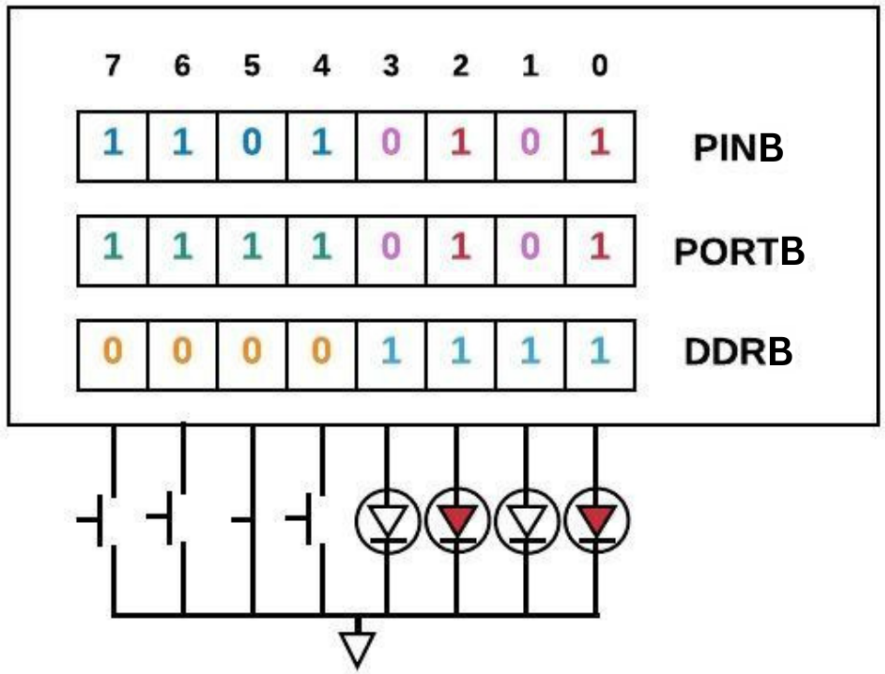

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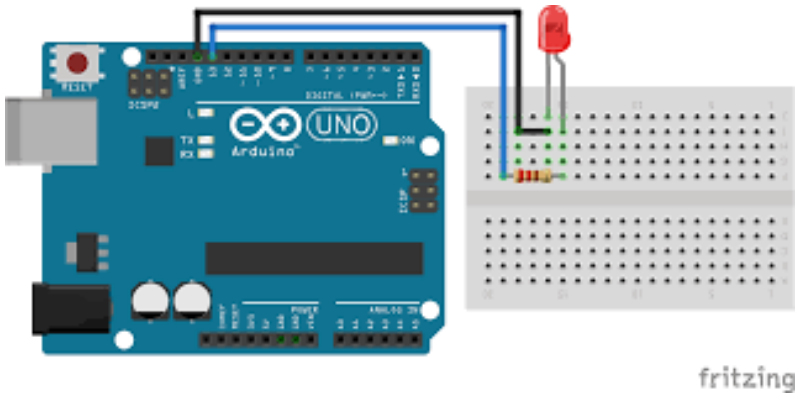

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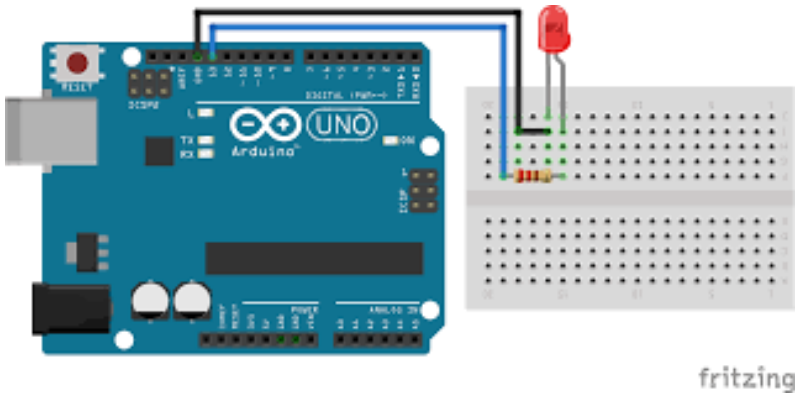

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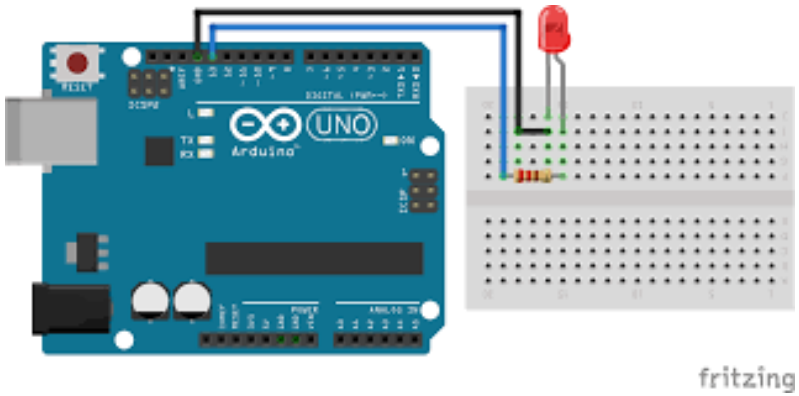

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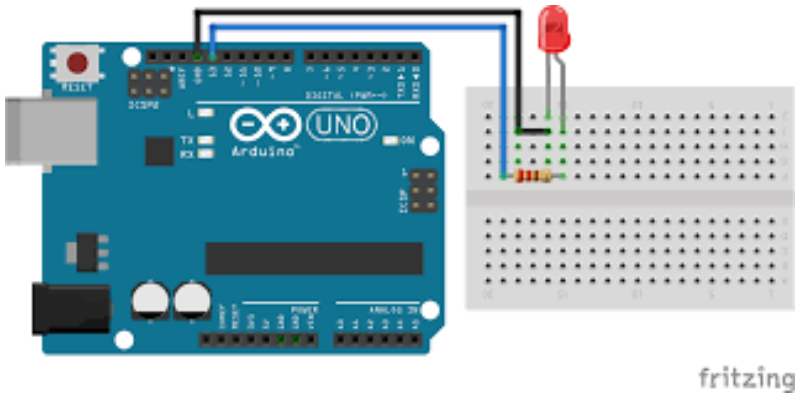

2. To turn ON LED: send logic HIGH on pin 5 of Port B

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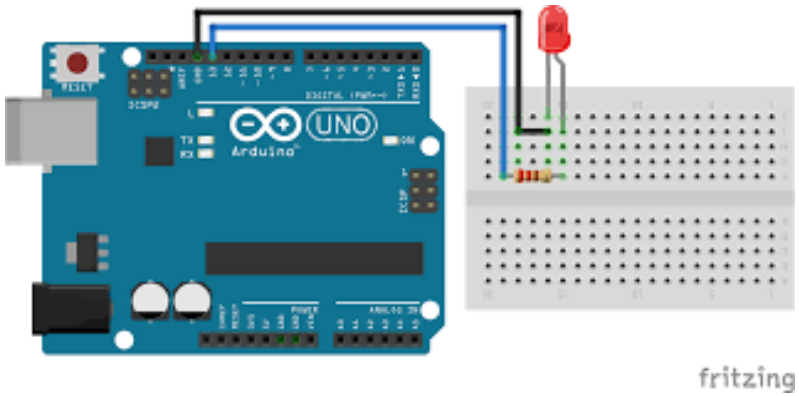

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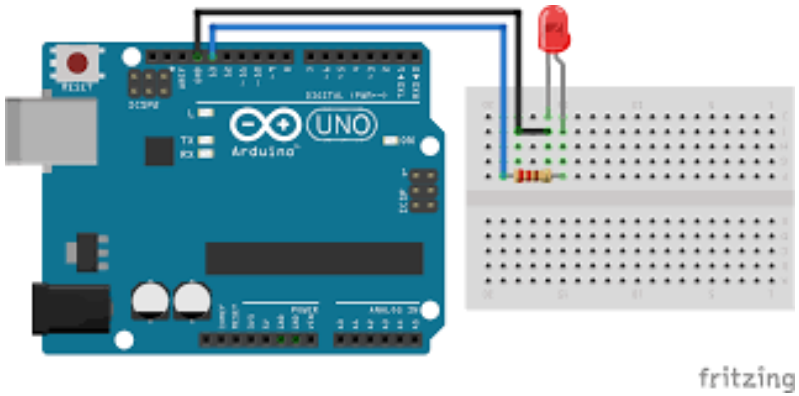

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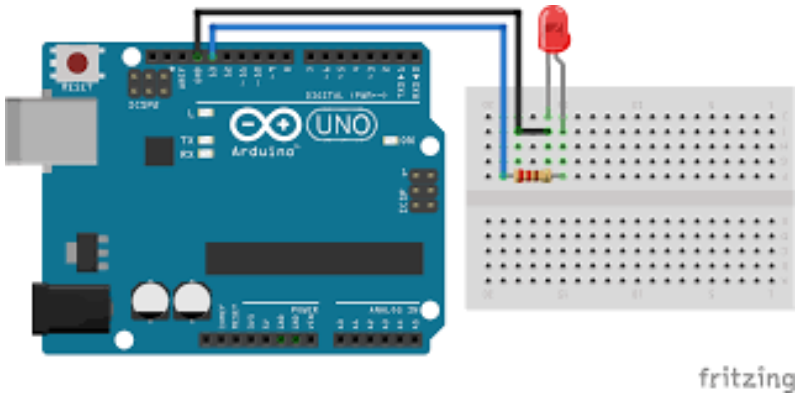

2. To turn ON LED: send logic HIGH on pin 5 of Port B

3. To turn OFF LED: send logic LOW on pin 5 of Port B

LED Program

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1. Configure PB.5 pin as Output.

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   DDRB = 0x20; // 0010 0000

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   PORTB = 0x20; // 0010 0000

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LED Program

1. Configure PB.5 pin as Output.

   DDRB = 0x20; // 0010 0000

2. To turn ON the LED set PB.5 output HIGH

   PORTB = 0x20; // 0010 0000

3. To turn OFF the LED set PB.5 output LOW

   PORTB = 0x00; // 0000 0000

LED Program

1. Configure PB.5 pin as Output.

   DDRB = 0x20; // 0010 0000

2. To turn ON the LED set PB.5 output HIGH

   PORTB = 0x20; // 0010 0000

3. To turn OFF the LED set PB.5 output LOW

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2. AVR is not bit addressable.
3. No 'address' to a specific bit.
4. Use of different masking operators.

Masking Operators

In general, there are three operators used for masking:

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- OR operator → to SET a particular bit
- AND operator → to RESET a particular bit
- EXOR operator → to TOGGLE a particular bit

Two more operators can be used:

- NOT operator
- Shift operators

NOT Operator

1. Purpose: To perform negation on all bits.

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2. Symbol: $\sim$

NOT Operator

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2. Symbol: $\backsim$
3. Example:

$A =$

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

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$\backsim A =$

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0	1	1	1	1	1	0	0

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1	0	0	0	0	0	1	1

A<<2 =

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	1	1	0	0

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A<<2 =

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	1	1	0	0

A>>2 =

B7	B6	B5	B4	B3	B2	B1	B0
0	0	1	0	0	0	0	0

OR Operator

1. Purpose: To SET particular bit/s.

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3. Truth Table:

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

Example

1. Example: Setting a bit :

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1. Example: Setting a bit :
   a. Consider register has data 0x83 (unknown to us). We want to set 2nd bit of register and keep rest of the data intact.

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

Example

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B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

   b. Expected output is:

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

Example

B7	B6	B5	B4	B3	B2	B1	B0
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Example

B7	B6	B5	B4	B3	B2	B1	B0
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OR

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	1	0	0

Example

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

OR

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	1	0	0

Output same as Expected output:

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

Example

B7	B6	B5	B4	B3	B2	B1	B0
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OR

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	1	0	0

Output same as Expected output:

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

1. register_name = register_name | 0x04;

Example

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

OR

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	1	0	0

Output same as Expected output:

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

1. register_name = register_name | 0x04;
2. register_name |= 0x04;

Example of Masking with Shift Operator

1. register_name |= 0x04;

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1. register_name |= 0x04;
2. 0x04 can also be written as 1<<2

Example of Masking with Shift Operator

1. register_name $|=$ 0x04;
2. 0x04 can also be written as 1<<2
3. In general, statement can be written as:

   Register_name $|= (1 << pin\_no)$

Example of Masking with Shift Operator

1. register_name $|=$ 0x04;
2. 0x04 can also be written as 1<<2
3. In general, statement can be written as:

   Register_name $|= (1 << pin\_no)$
4. For setting multiple bits at once the statement can be written as:

   Register_name $|= ((1 << pin\_no1) \mid (1 << pin\_no2))$

AND Operator

1. Purpose: To RESET particular bit/s.

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3. Truth Table:

A	B	Output
0	0	0
0	1	0
1	0	0
1	1	1

Example

1. Example: Resetting a bit :

Example

1. Example: Resetting a bit :
   a. Consider register has data 0x87 (unknown to us). We want to reset pin 2 and keep rest of the data intact.

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

Example

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Example

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   b. Expected output is:

B7	B6	B5	B4	B3	B2	B1	B0
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Example

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B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

   b. Expected output is:

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

Example

B7	B6	B5	B4	B3	B2	B1	B0
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Example

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

AND

B7	B6	B5	B4	B3	B2	B1	B0
1	1	1	1	1	0	1	1

Example

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

AND

B7	B6	B5	B4	B3	B2	B1	B0
1	1	1	1	1	0	1	1

Output same as Expected output:

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

Example

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

AND

B7	B6	B5	B4	B3	B2	B1	B0
1	1	1	1	1	0	1	1

Output same as Expected output:

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

1. register_name = register_name & 0xFB;

Example

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	1	1	1

AND

B7	B6	B5	B4	B3	B2	B1	B0
1	1	1	1	1	0	1	1

Output same as Expected output:

B7	B6	B5	B4	B3	B2	B1	B0
1	0	0	0	0	0	1	1

1. register_name = register_name & 0xFB;
2. register_name &= 0xFB;

Example of Masking with Shift Operator

1. register_name &= 0xFB;

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1. register_name &= 0xFB;
2. 0xFB can also be written as $\backsim$ (1 << 2)

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   Register_name & = $\backsim (1 << pin\_no)$

Example of Masking with Shift Operator

1. register_name &= 0xFB;
2. 0xFB can also be written as $\backsim (1 << 2)$
3. In general, statement can be written as:

   Register_name & = $\backsim (1 << pin\_no)$
4. For resetting multiple bits at once the statement can be written as:

   Register_name &= $\backsim ((1 << pin\_no1) \mid (1 << pin\_no2))$

LED Example with Masking

1. Configure PB.5 pin as Output.

   DDRB $|=$ (1 $<<$ 5);

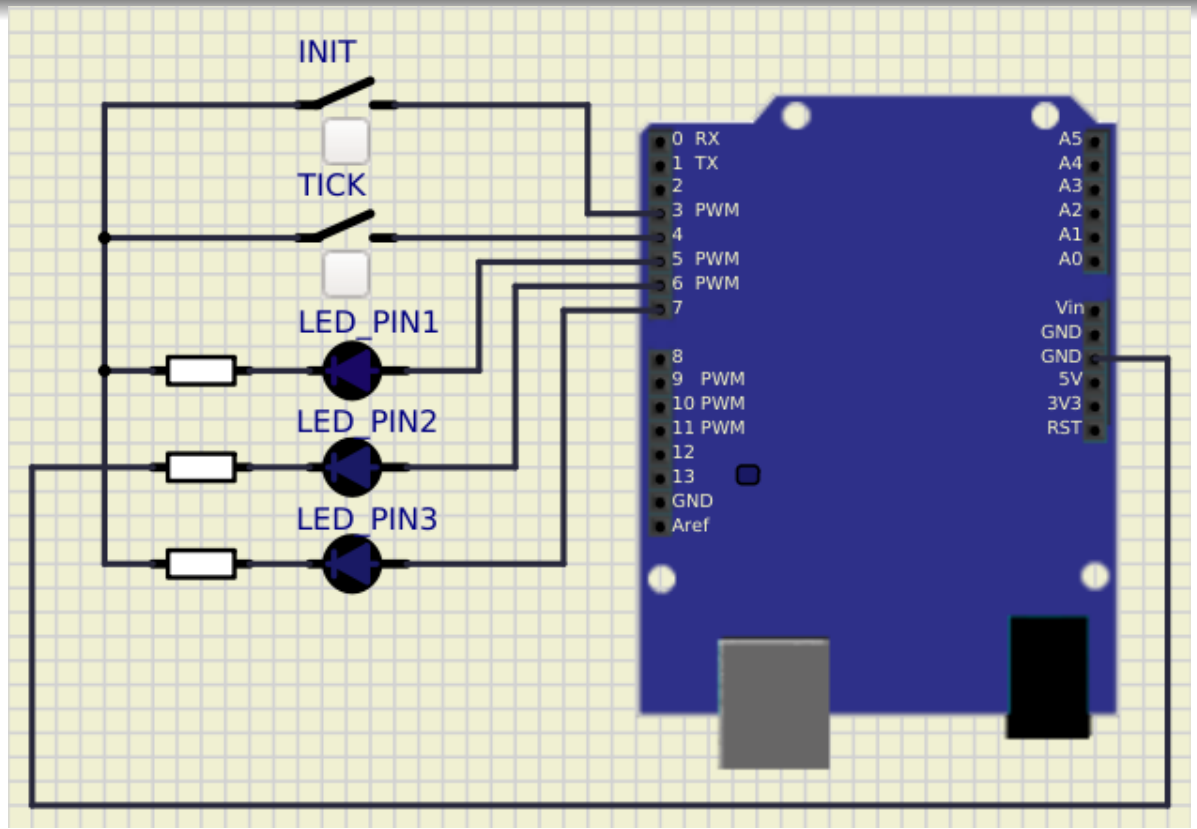
2. To turn ON the LED set PB.5 output HIGH

   PORTB $|=$ (1 $<<$ 5);

3. To turn OFF the LED set PB.5 output LOW

   PORTB &$=$ $\backsim$ (1 $<<$ 5);

3 Bit Counter



1. Initial – Into non-counting mode
2. INIT – Goes into counting mode
3. TICK – At every Tick counter increments
4. Once counter reaches 7 – Goes back to non-counting mode

EXOR Operator

1. Purpose: To TOGGLE particular bit.

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2. Symbol: ^

EXOR Operator

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2. Symbol: $\wedge$
3. Truth Table:

A	B	Output
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0	1	1
1	0	1
1	1	0

EXOR Operator

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2. Symbol: ^
3. Truth Table:

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

EXOR Operator

1. Purpose: To TOGGLE particular bit.
2. Symbol: ^
3. Truth Table:

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

4. For one bit:
   Register_name ^ = (1 << pin_no)

EXOR Operator

1. Purpose: To TOGGLE particular bit.
2. Symbol: ^
3. Truth Table:

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

4. For one bit:
   Register_name ^ = (1 << pin_no)
5. For toggling multiple bits:
   Register_name ^= ((1 << pin_no1) | (1 << *pin_no2*))

Thank You!

Post your queries on: support@e-yantra.org