Embedded Systems: Where Hardware and Software Meet

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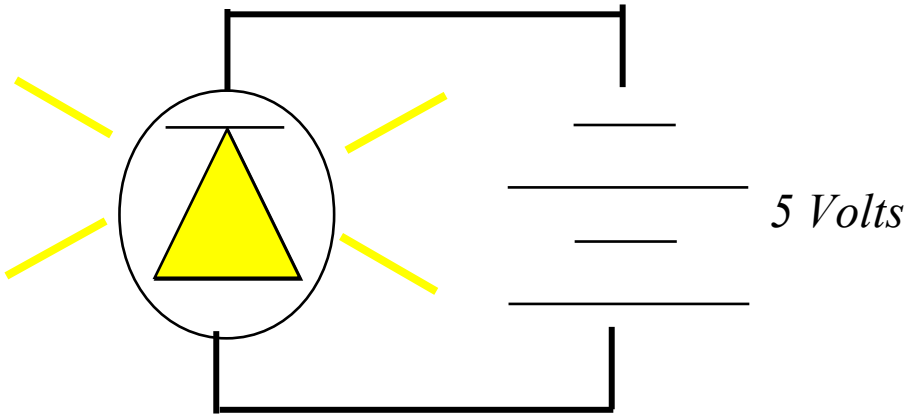
Embedded Systems: Where Hardware and Software Meet

1. Computer Systems Basics
2. Light-Emitting Diode (LED)
3. Stepper Motor
4. DC Motor

A Simple Circuit

A LED is a light-emitting diode - It's a small light



A Simple Circuit

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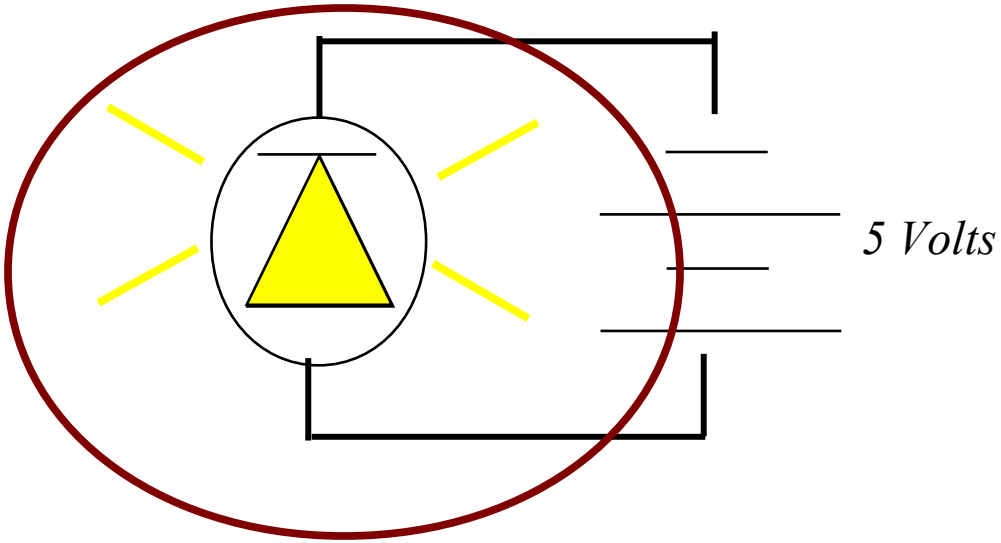
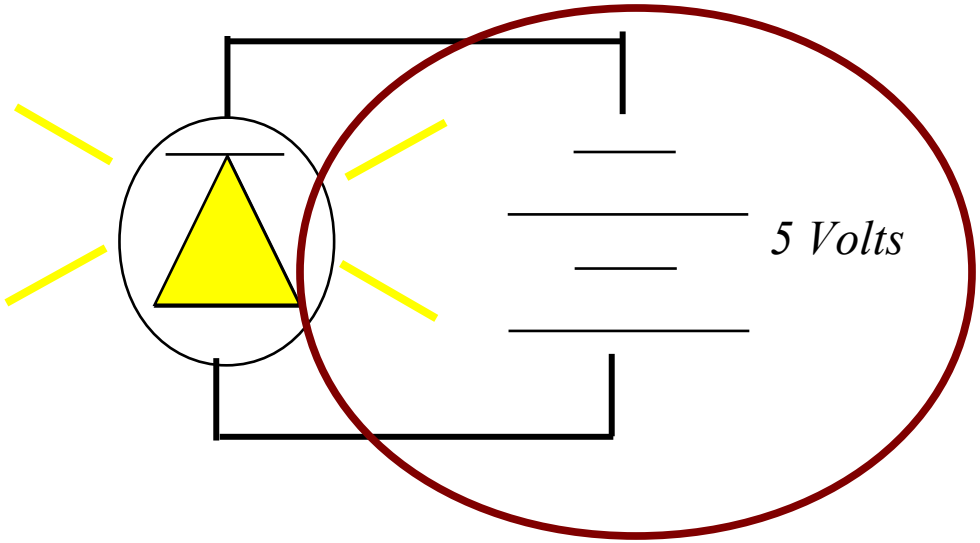


A Simple Circuit

The LED needs power. We need a voltage source

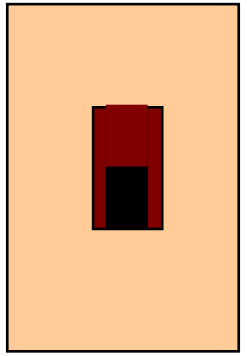


How can we turn the light on and off ?

A Switch

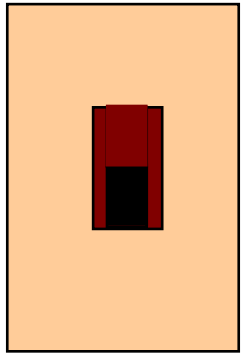
A switch is:

- ON or OFF
- CLOSED or OPEN
- ONE (1) or ZERO (0)



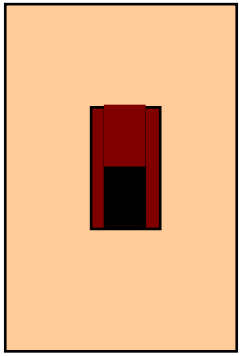
A Switch

ON or **CLOSED** or **ONE**



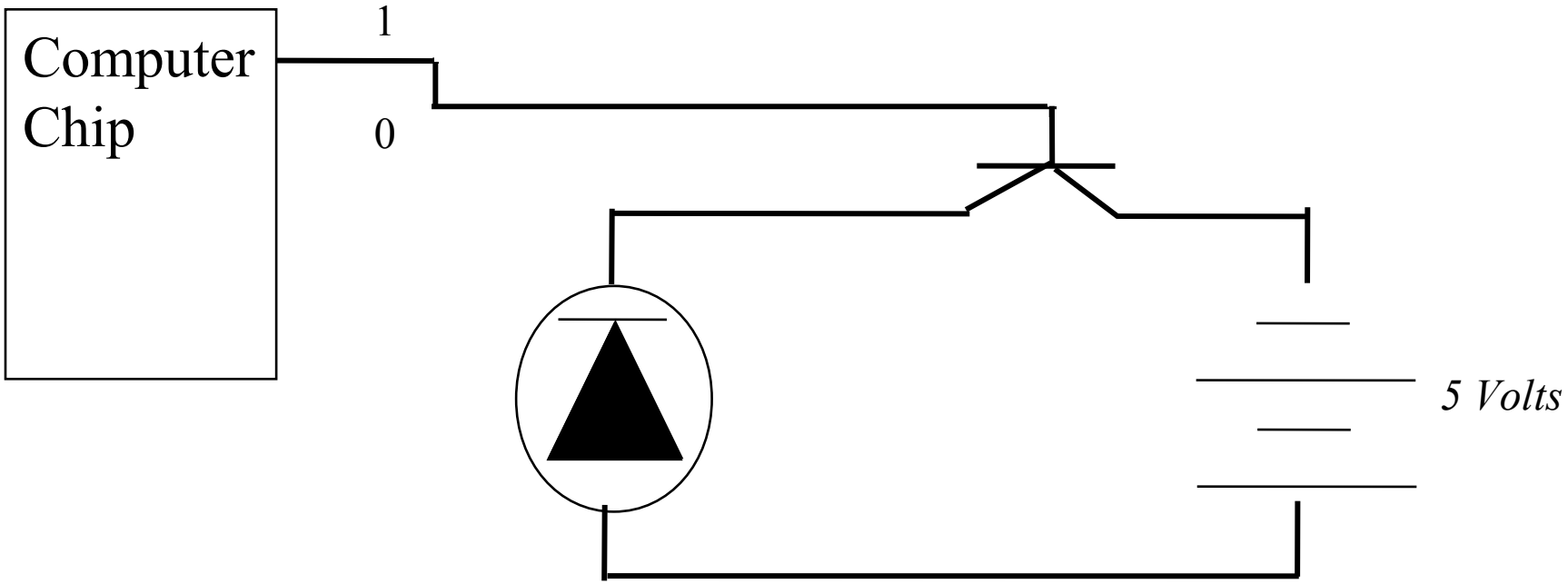
A Switch

OFF or **OPEN** or **ZERO**



Computer Controlled Switch

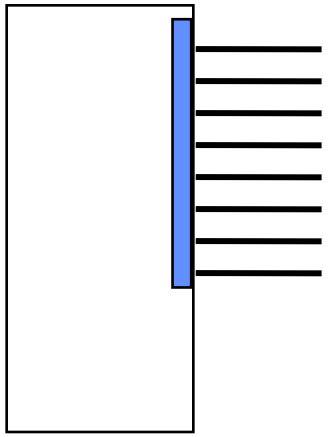
A computer chip can be connected to a circuit



The computer acts as the switch

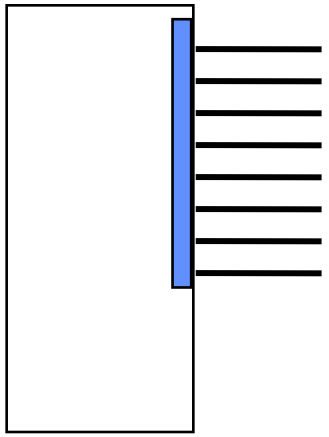
Pins and Ports

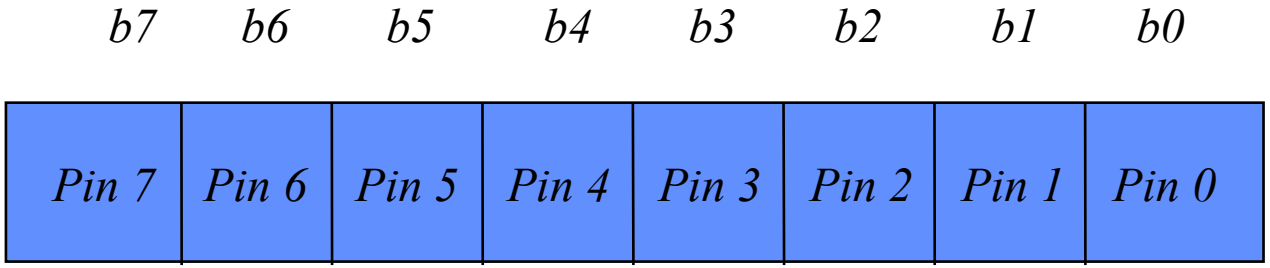
- Each input or output is called a “pin”
- A computer chip generally has many pins
- Each pin sends/receives 1s and 0s



Pins and Ports

- A port is a named collection of pins
  - A byte-sized port is 8-bits long
- Pins (or bits) are identified from 0 … n-1



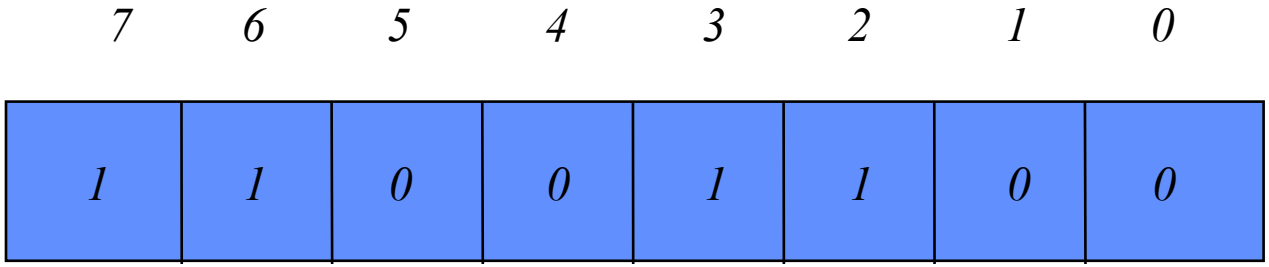


Sending Signals Through Ports

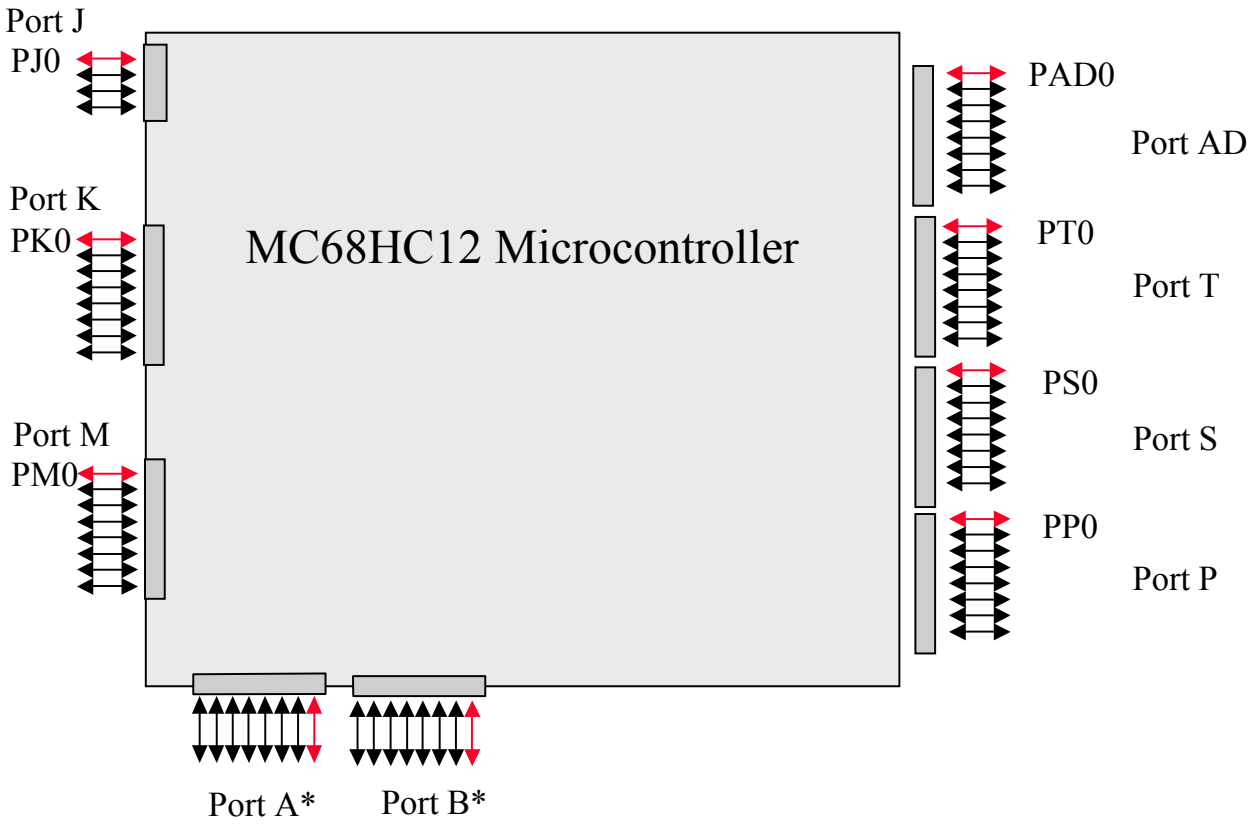
Because a port is named, our software can set and clear a pin on a port

Example:

PORTK = 11001100b;

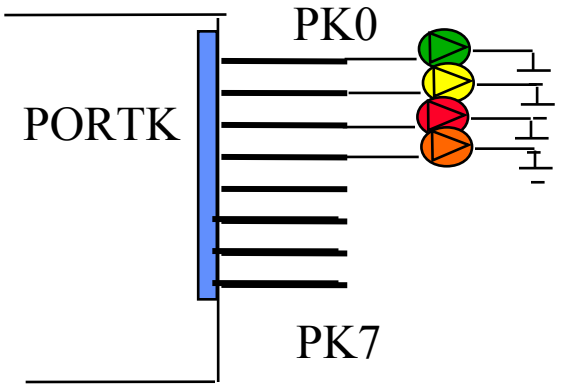


MC68HC12 Microcontroller



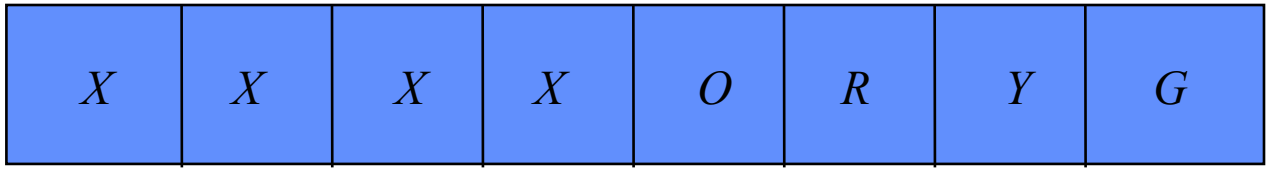
Turning on LEDs

- Suppose that we have four LEDs connected to PORTK's four "least significant" pins



X	*X*	*X*	*X*	*O*	*R*	*Y*	*G*

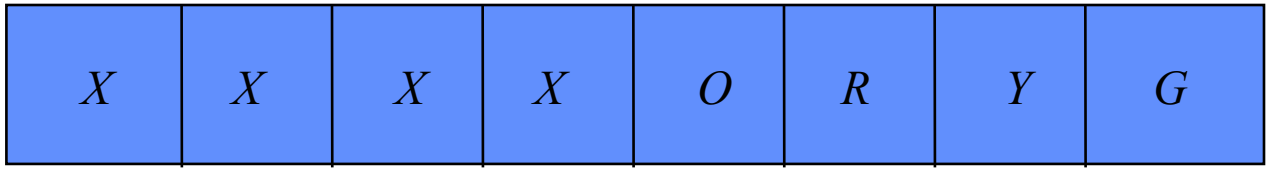
LED Examples



Turning on all four LEDS:

PORTK = ????????

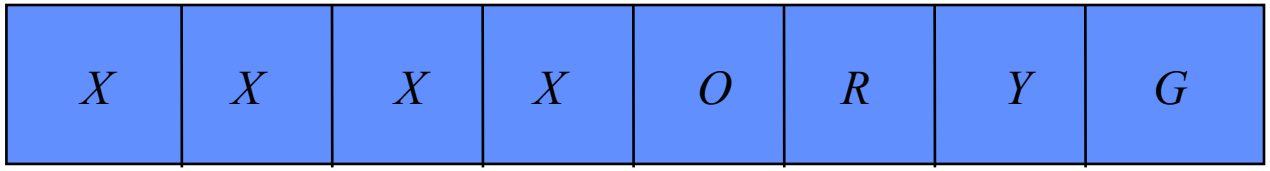
LED Examples



Turning on all four LEDS:

PORTK = 00001111

LED Examples



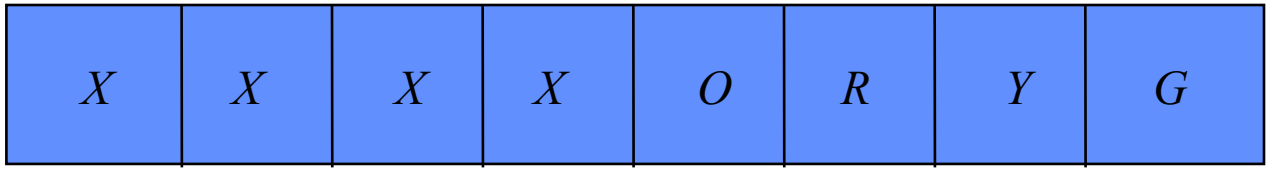
Turning on all four LEDS:

PORTK = 00001111

Turning off all four LEDS:

PORTK = ????????

LED Examples



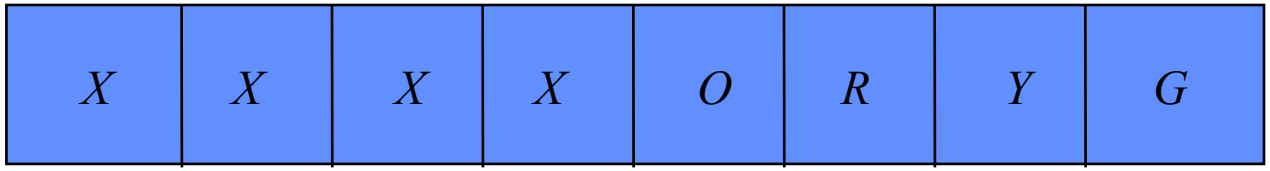
Turning on all four LEDS:

PORTK = 00001111

Turning off all four LEDS:

PORTK = 00000000

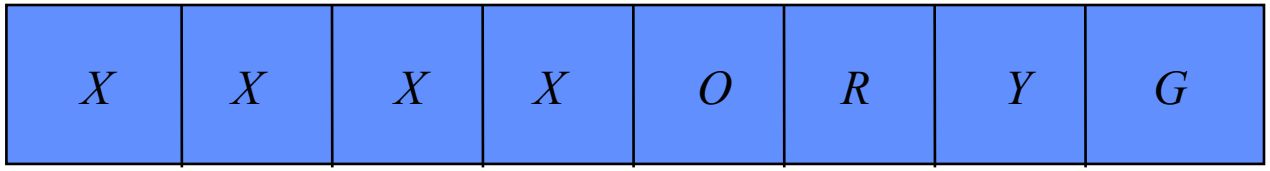
LED Examples



Turning on orange/yellow and off red/green:

PORTK = ????????

LED Examples

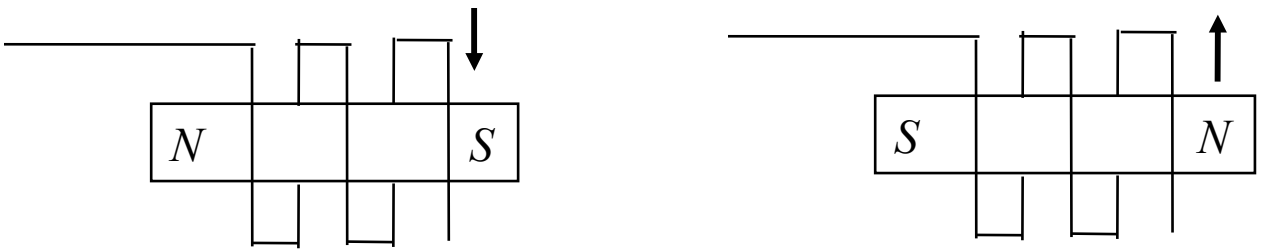


Turning on orange/yellow and off red/green:

PORTK = 00001010

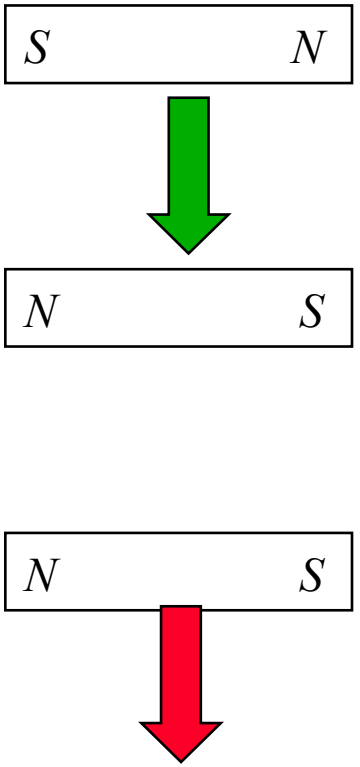
Stepper Motors

- Used for precision control in robotics
- Motors make small steps in turning, giving a high degree of control
- Based on electromagnetism – electricity and magnetism

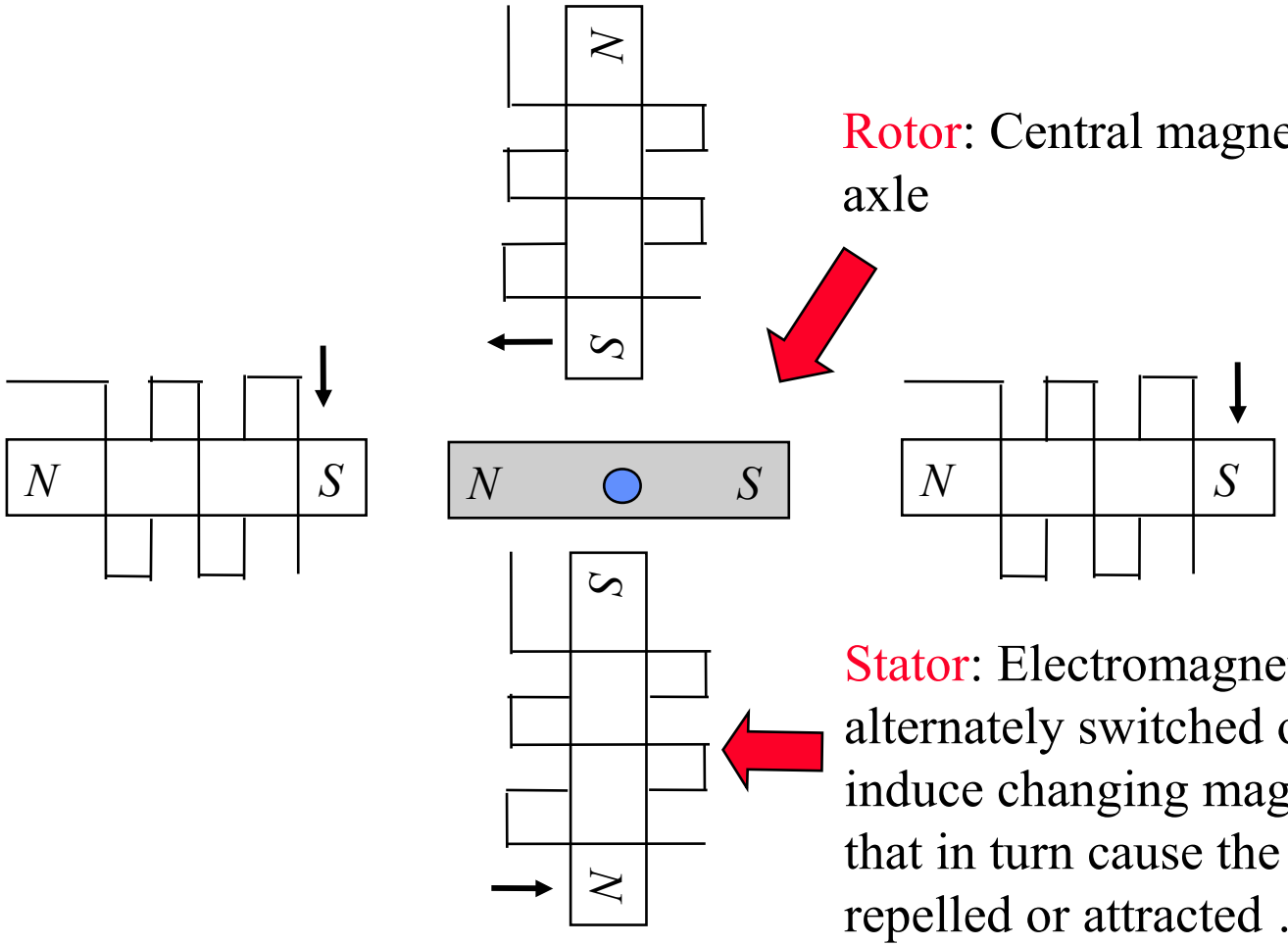


Magnetism Review

- Magnets have a north (N) and south (S)
- Opposites attract (N and S) but likes repel (N and N / S and S)



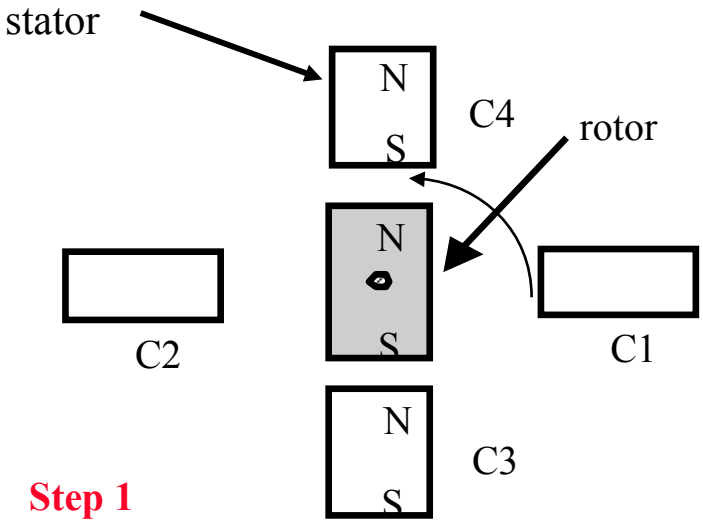
4-Stator Stepper Motor



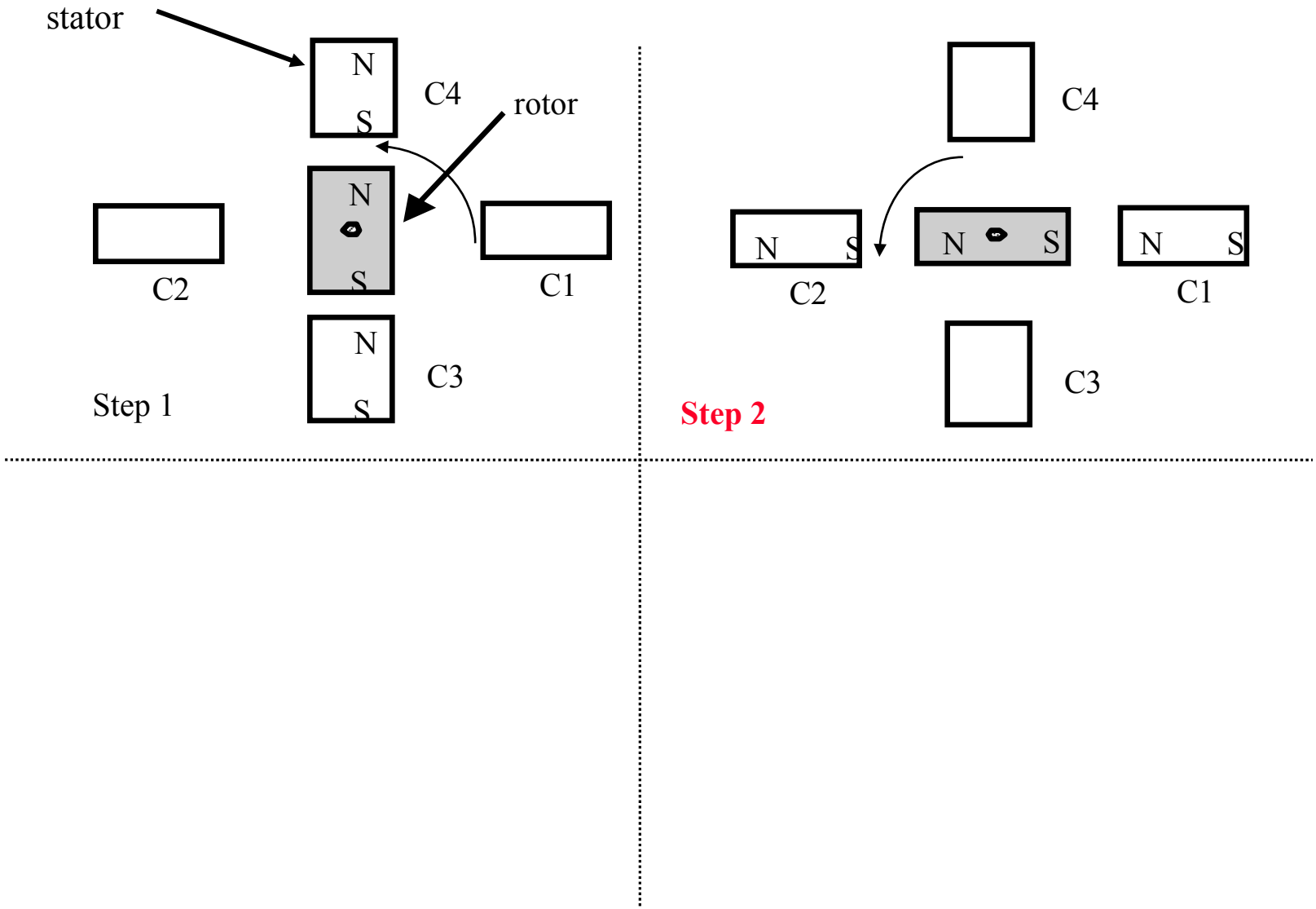
Rotor: Central magnet on an axle

Stator: Electromagnets that are alternately switched on/off to induce changing magnetic fields that in turn cause the rotor to be repelled or attracted … causing motion.

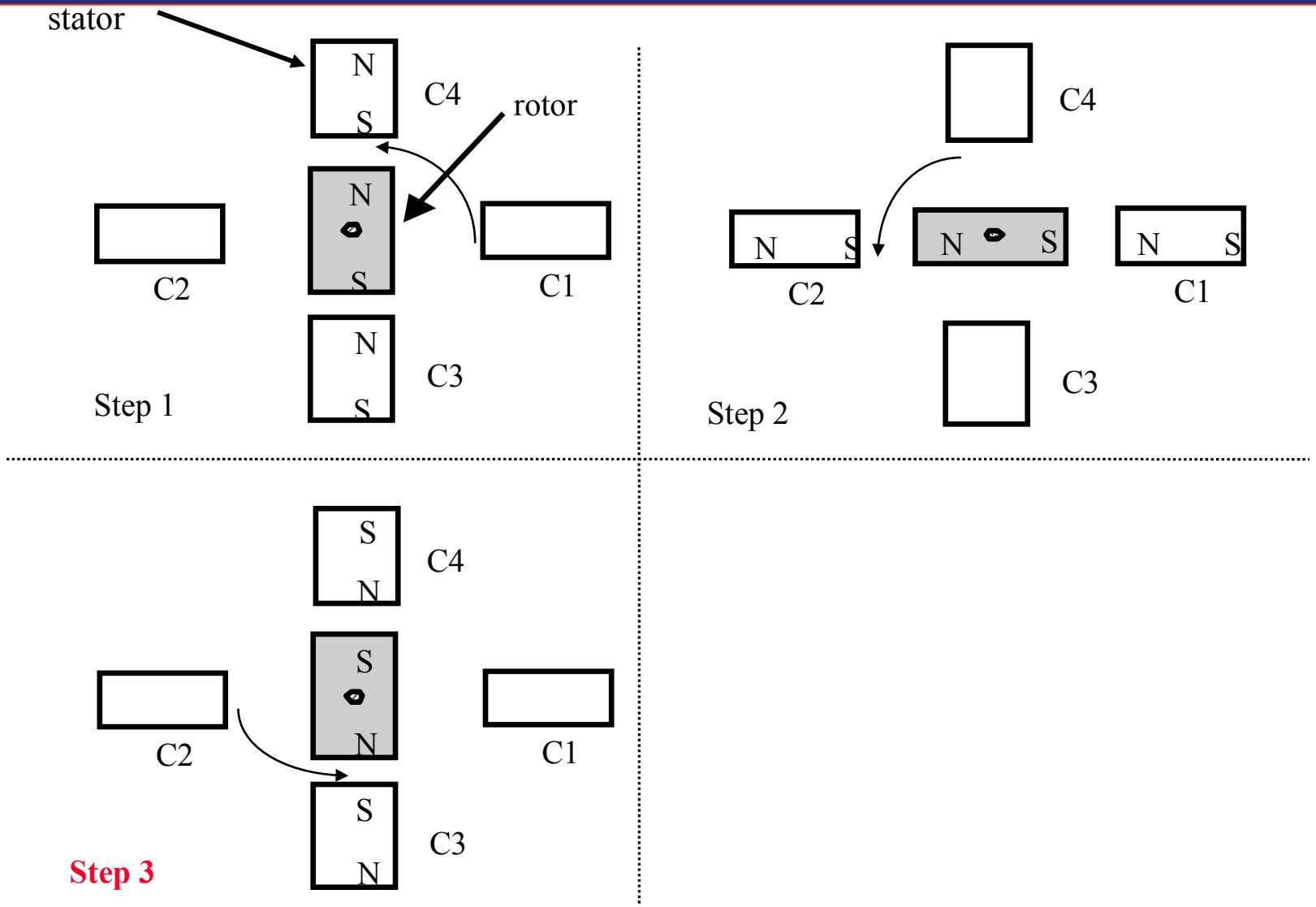
Stepper Motor Example



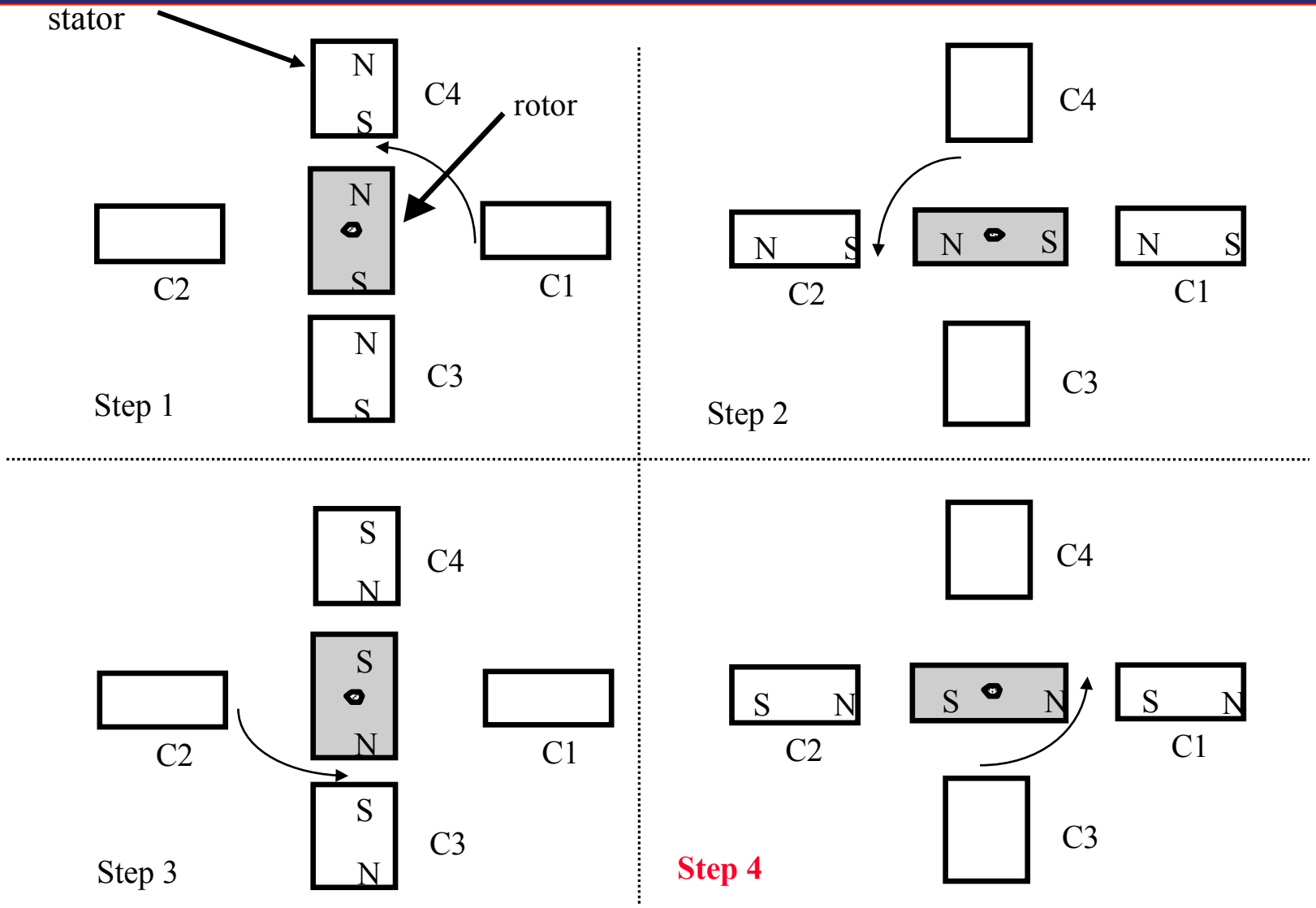
Stepper Motor Example



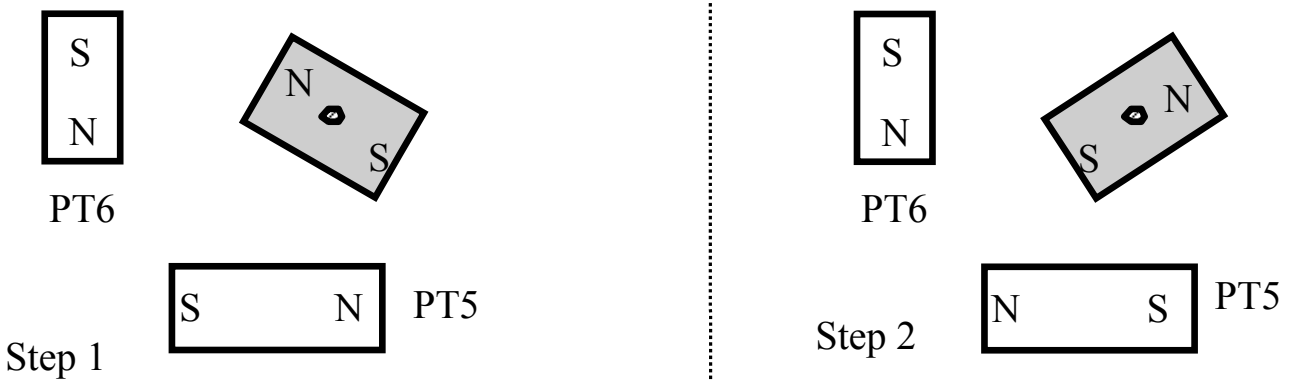
Stepper Motor Example



Stepper Motor Example



2-Stator Stepper Motor



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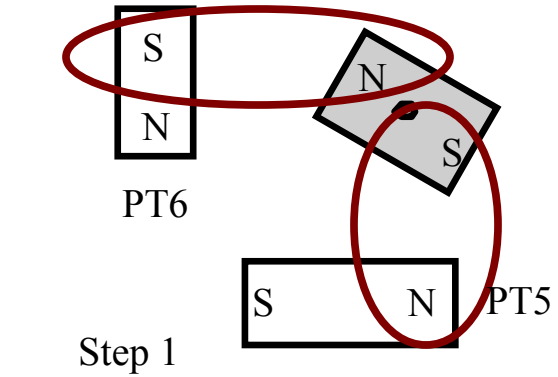

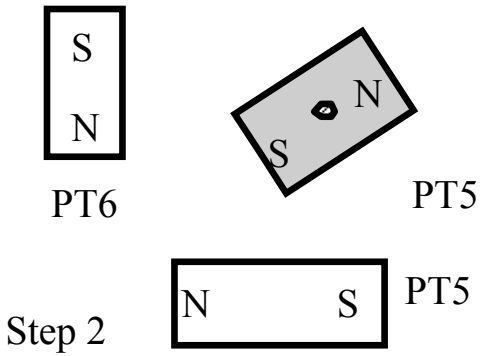

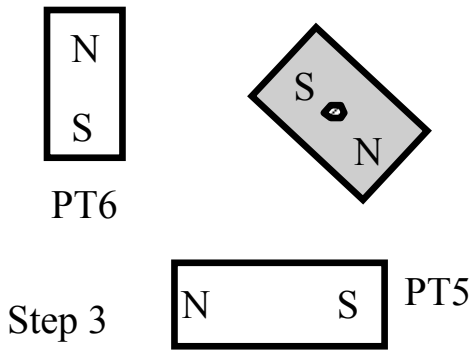

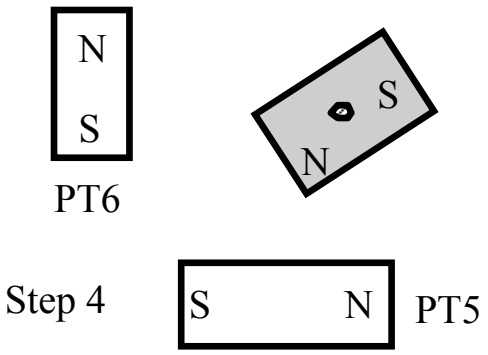

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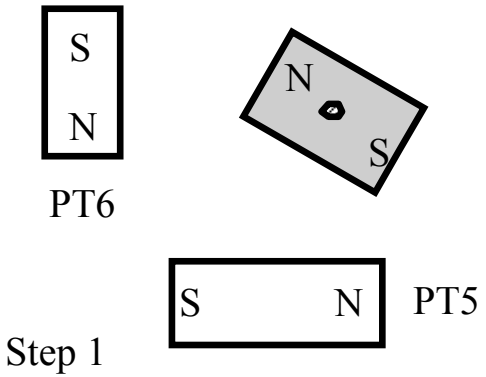
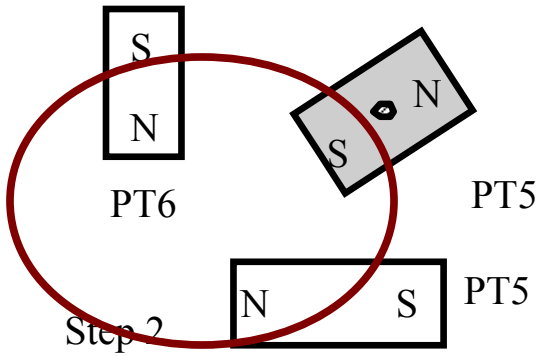
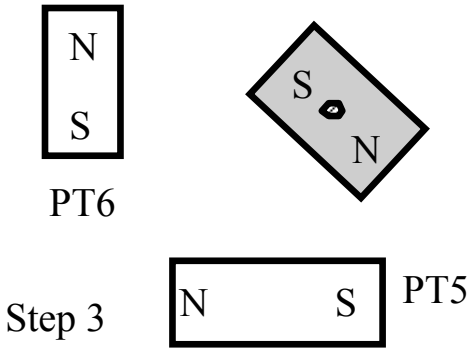
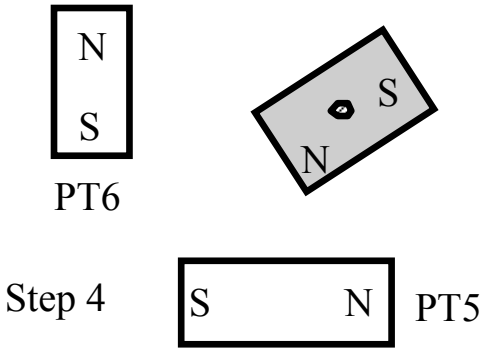
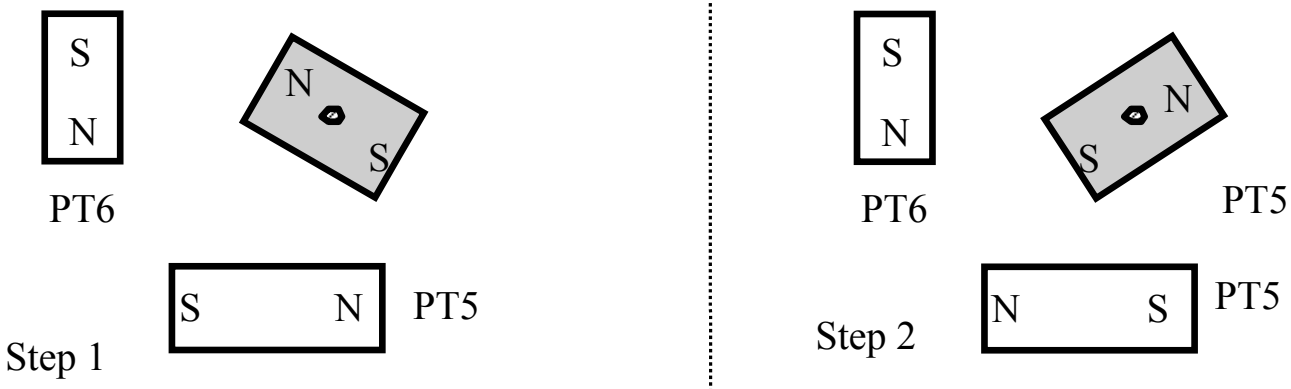








2-Stator Stepper Motor



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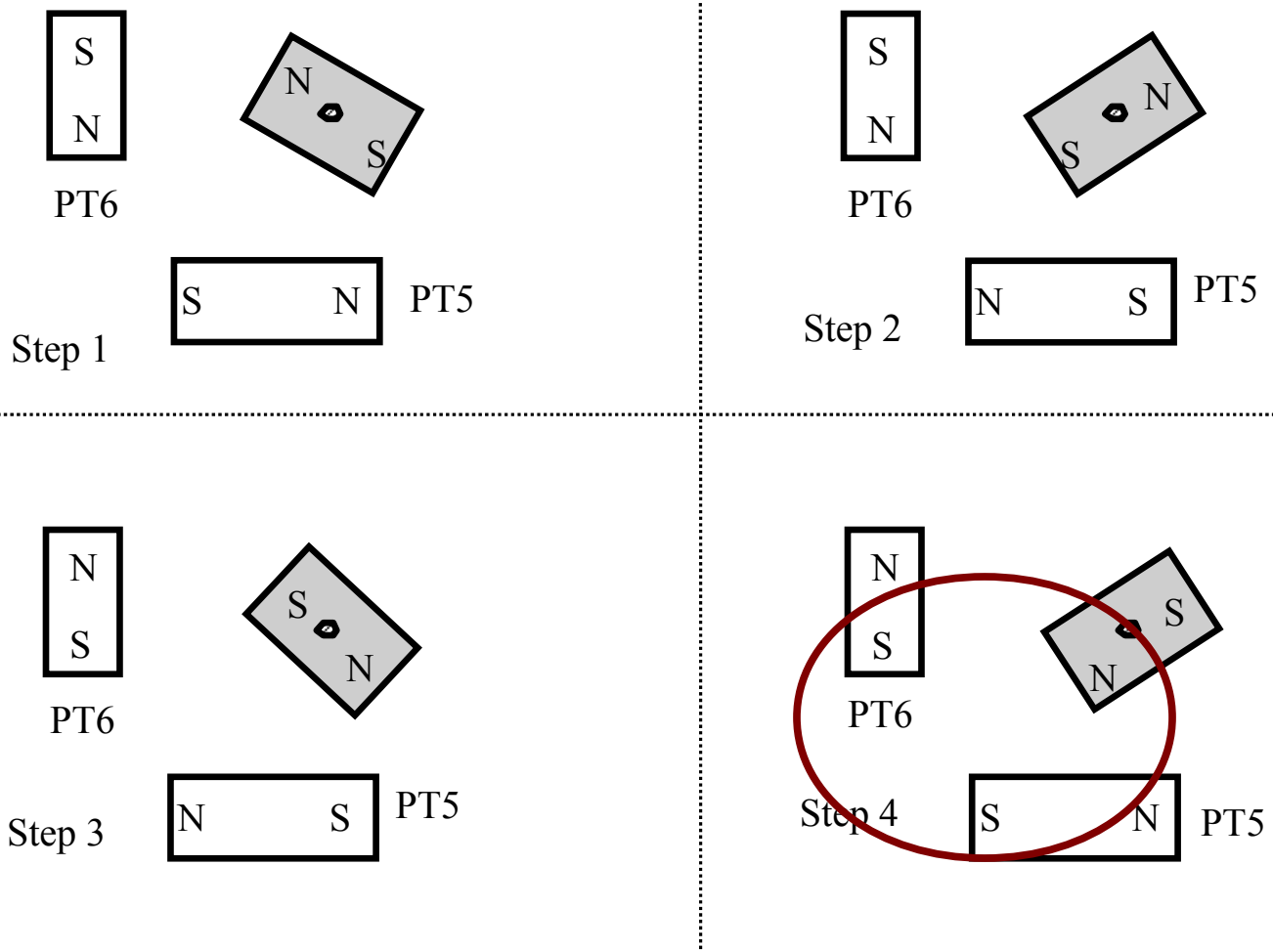
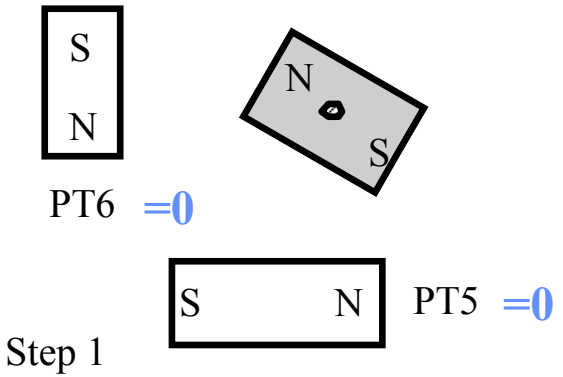
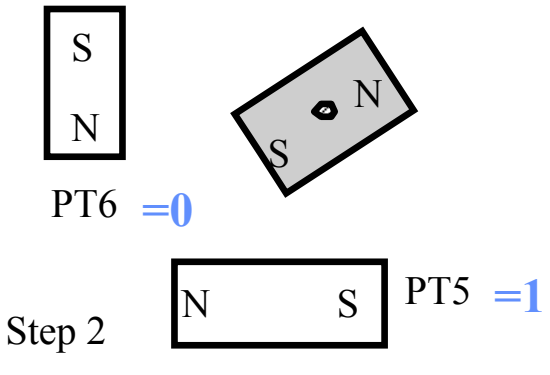
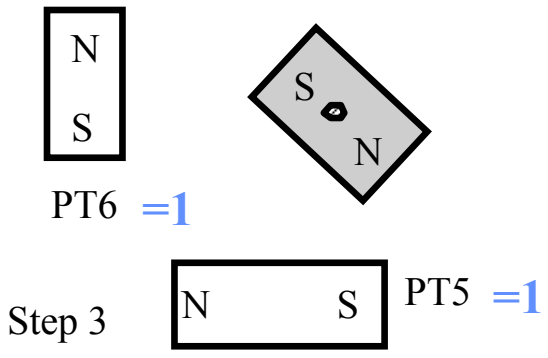
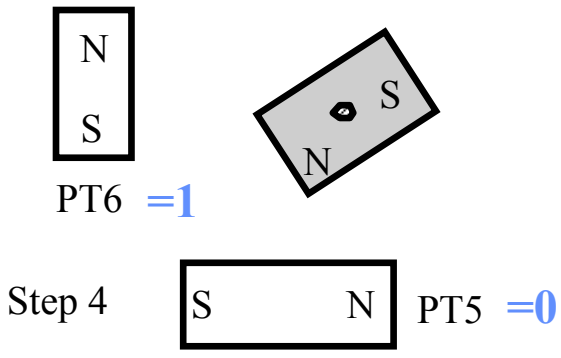


Controlling the 2-Stator Stepper

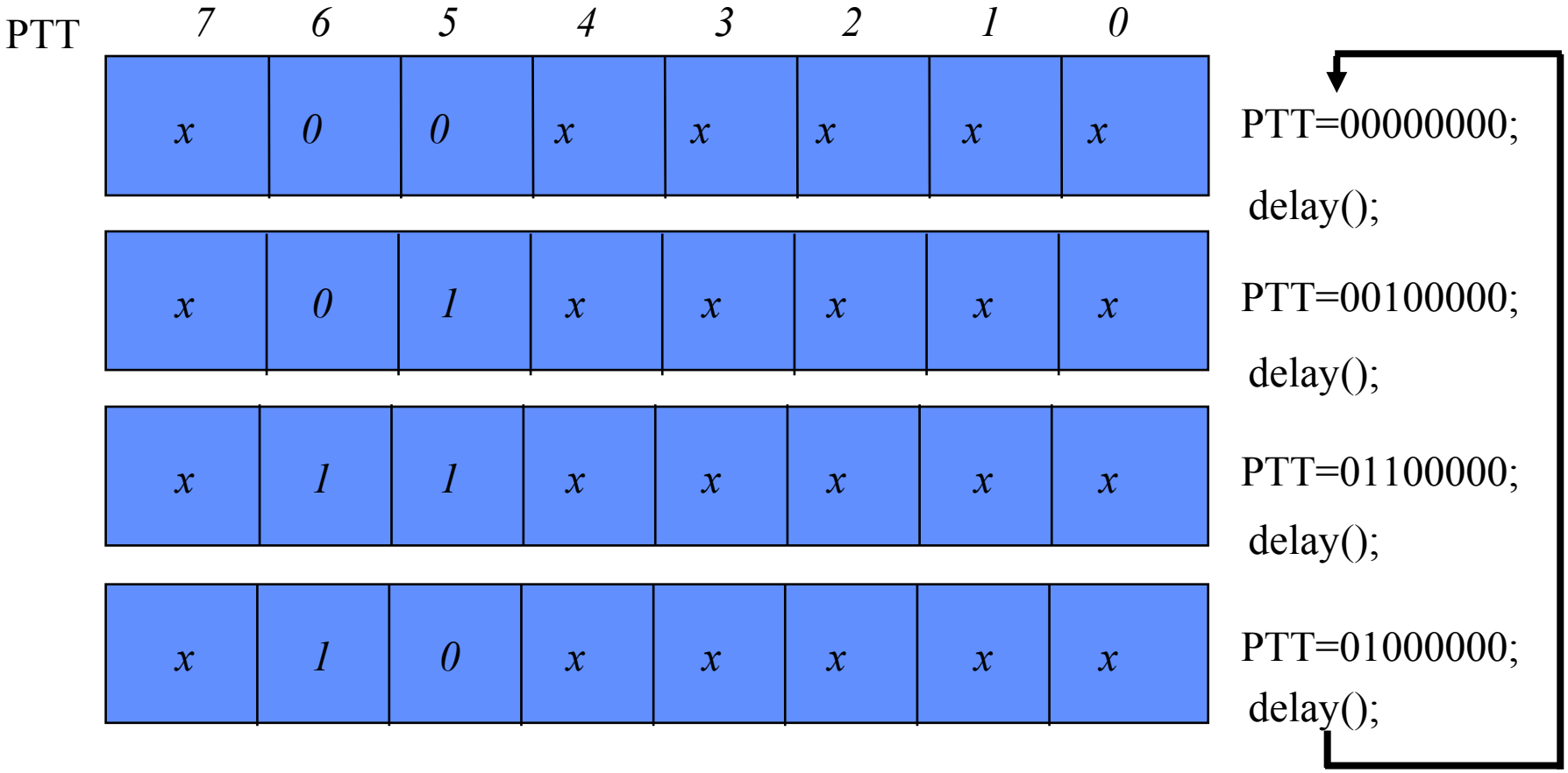








Turning the Stepper Motor



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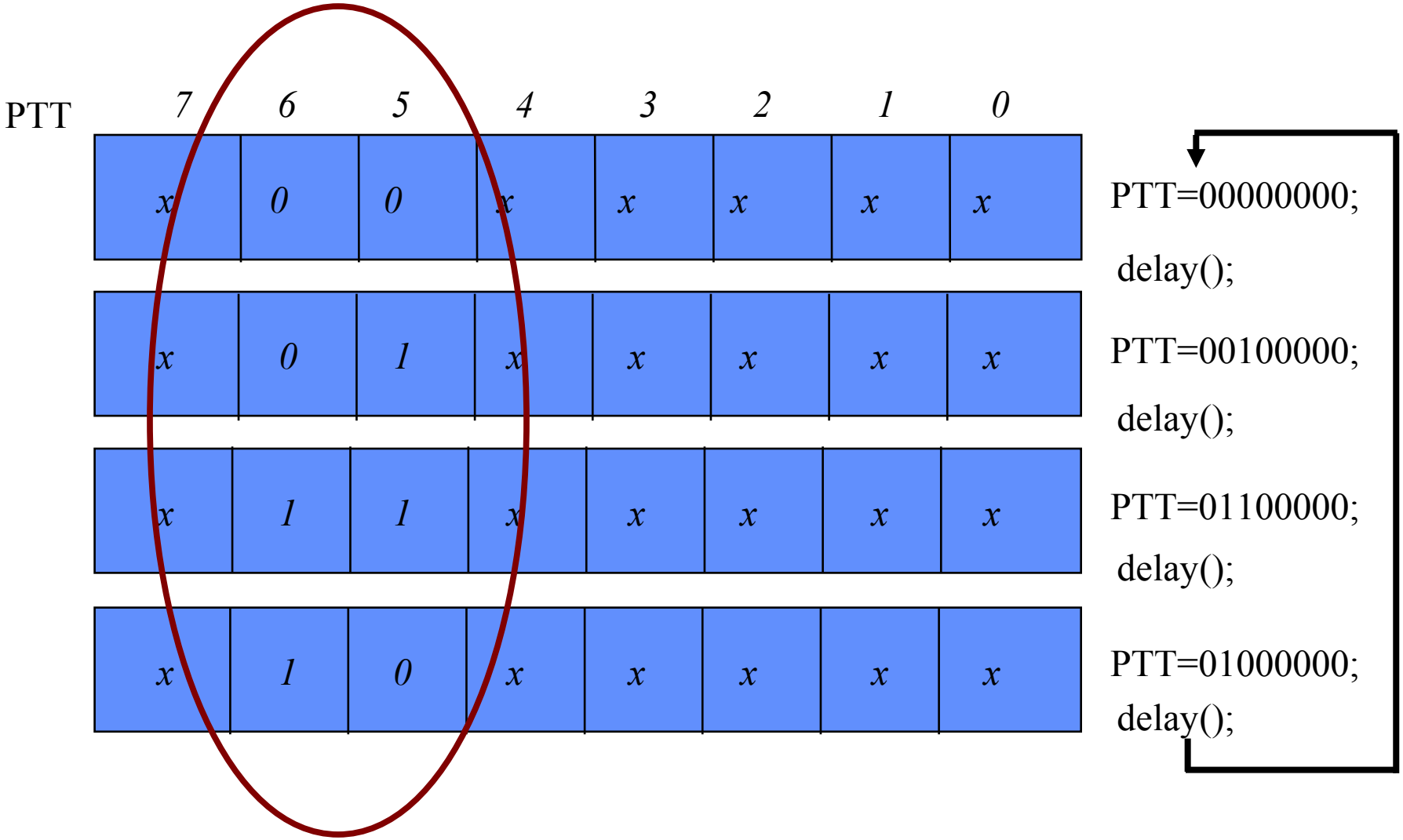

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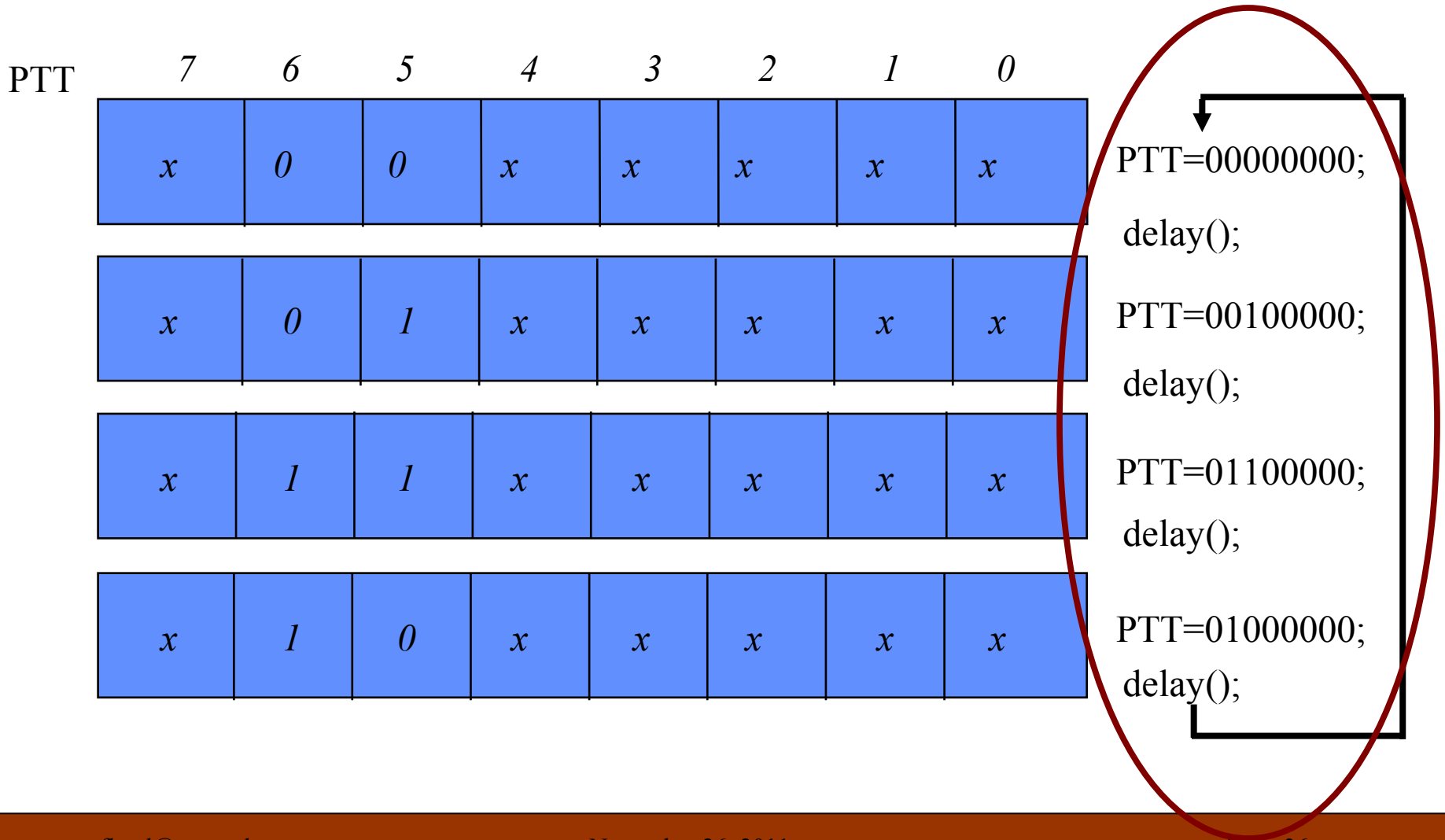
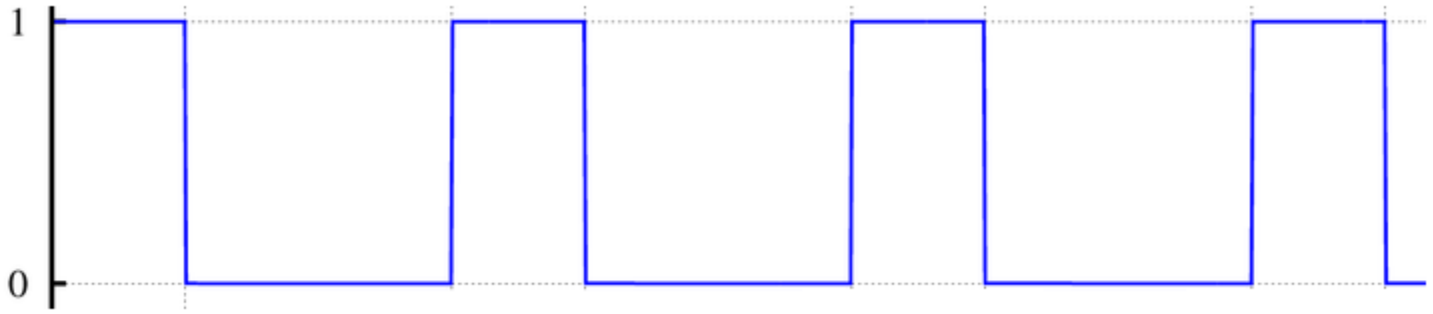


Pulse Width Modulation (PWM)

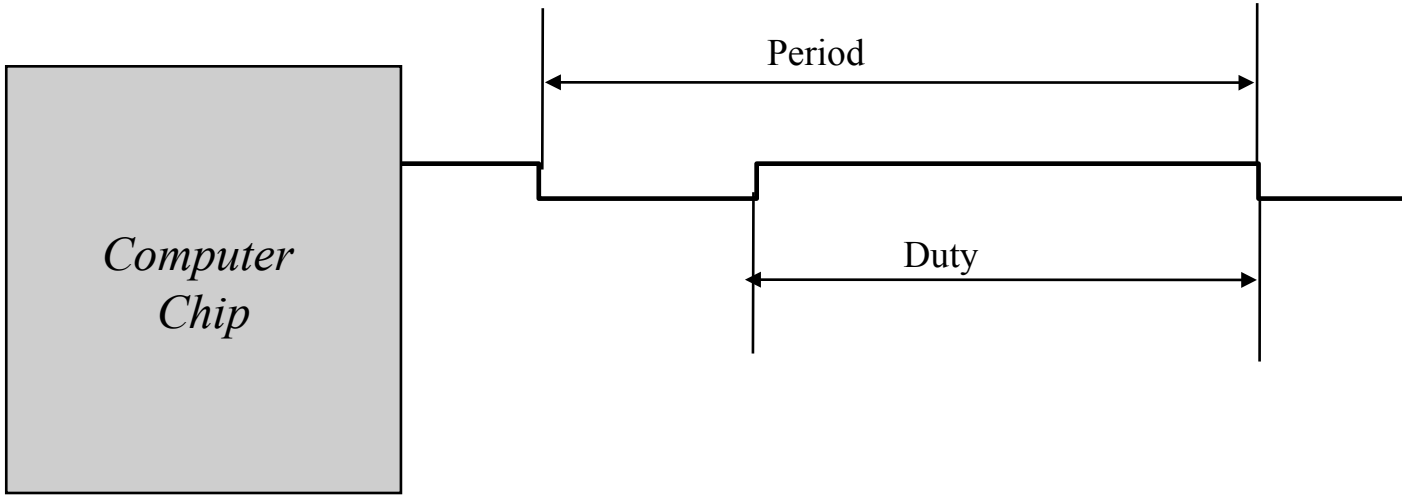
Automatic continuous generation of a waveform on a given port's pin



Not always a 1 or a 0

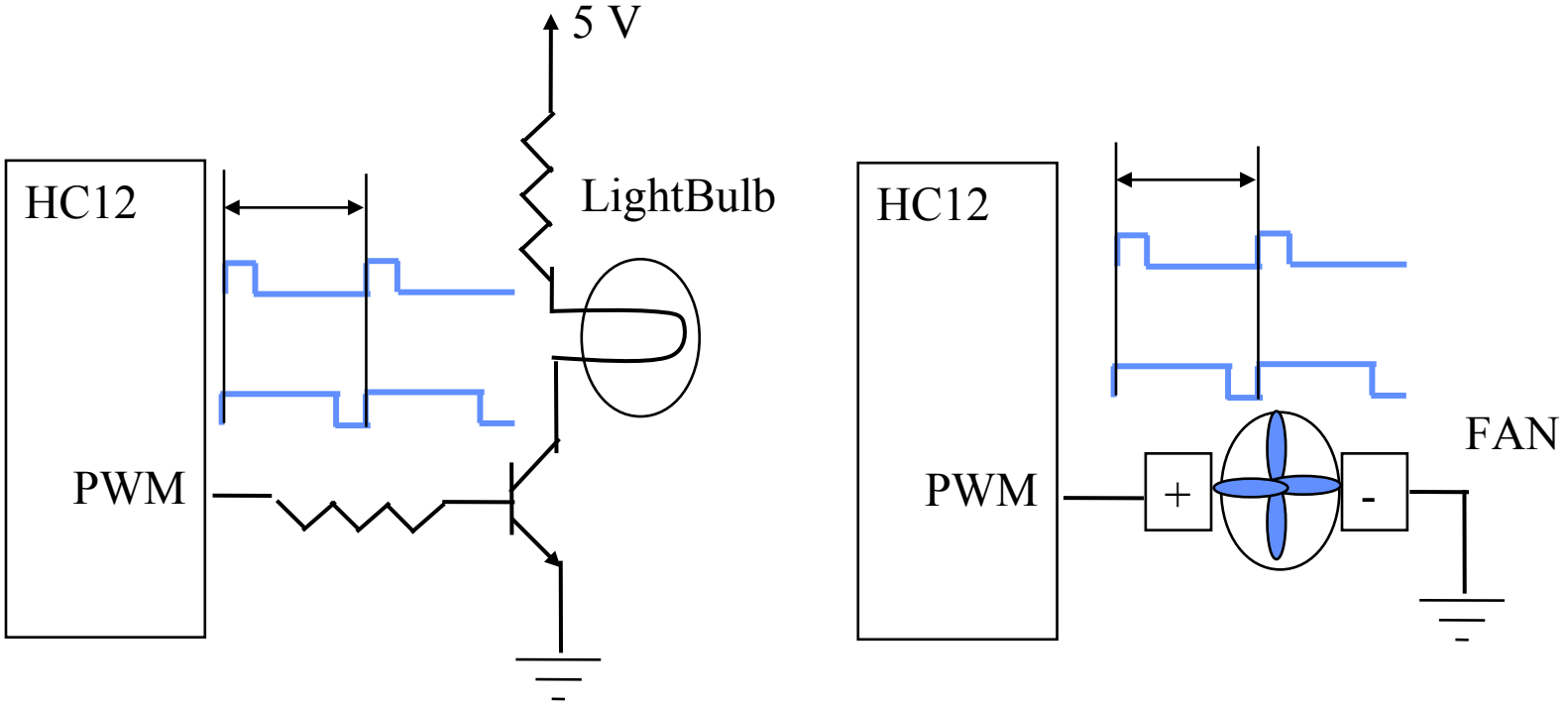
Pulse Width Modulation (PWM)

Initialize the **period** and **duty** and the signal will generate automatically



PWM with Lights and Fans

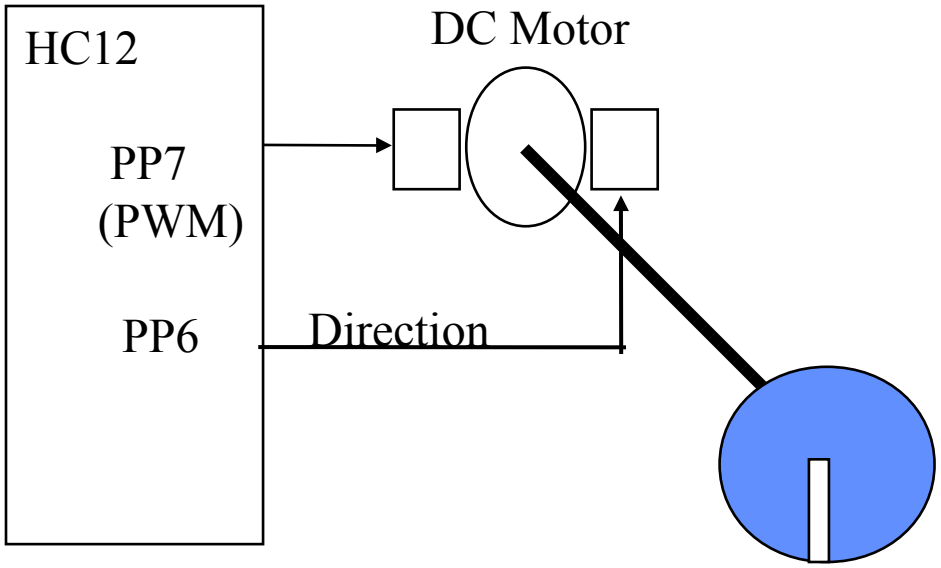
Circuits where the behaviour is proportional to the **average** current/voltage



*If duty is **50%** of period the average voltage will be **50%** of maximum voltage*

DC Motor

- A bidirectional motor
- We use PWM to **control the speed**
- We use another port to **control direction**



Sample Code

```
while(true) {
    // Choose your direction.
    PTP = 0b00000000;  // Counter-Clockwise
    // PTP = 0b01000000;  // Clockwise
    // Speed up
    for(duty = 20; duty <= 30; duty++) {
        PWMDTY7 = duty;
        delay(10);
    }
    // Slow down
    for(duty = 30; duty >= 15; duty--) {
        PWMDTY7 = duty;
        delay(10);
    }
}
```

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Sample Code

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while(true) {
    // Choose your direction.
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    // Speed up
    for(duty = 20; duty <= 30; duty++) {
        PWMDTY7 = duty;
        delay(10);
    }

    // Slow down
    for(duty = 30; duty >= 15; duty--) {
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Sample Code

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    for(duty = 20; duty <= 30; duty++) {
        PWMDTY7 = duty;
        delay(10);
    }
    // Slow down
    for(duty = 30; duty >= 15; duty--) {
        PWMDTY7 = duty;
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Sample Code

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    }
}
```

Sample Code

```
while(true) {
    // Choose your direction.
    PTP = 0b00000000;  // Counter-Clockwise
    // PTP = 0b01000000;  // Clockwise
    // Speed up
    for(duty = 20; duty <= 30; duty++) {
        PWMDTY7 = duty;
        delay(10);
    }
    // Slow down
    for(duty = 30; duty >= 15; duty--) {
        PWMDTY7 = duty;
        delay(10);
    }
}
```

Question?

Did this all make sense?