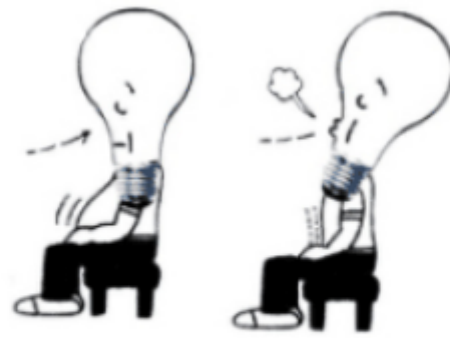# Project 2: Breathing Light

Breathing light

1. Description

In the previous lesson, we control LED on and off and to blink.
In this project, we will control LED brightness through PWM to simulate breathing effect. Similarly, you can change the step length and delay time in the code so as to demonstrate different breathing effect.

PWM is a means of controlling the analog output via digital means. Digital control is used to generate square waves with different duty cycles (a signal that constantly switches between high and low levels) to control the analog output.
In general, the input voltage of port are 0V and 5V. What if the 3V is required? Or what if switch among 1V, 3V and 3.5V? We can't change resistor constantly. For this situation, we need to control by PWM.
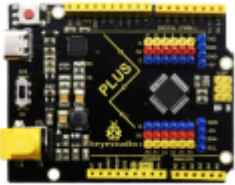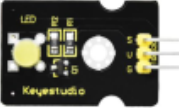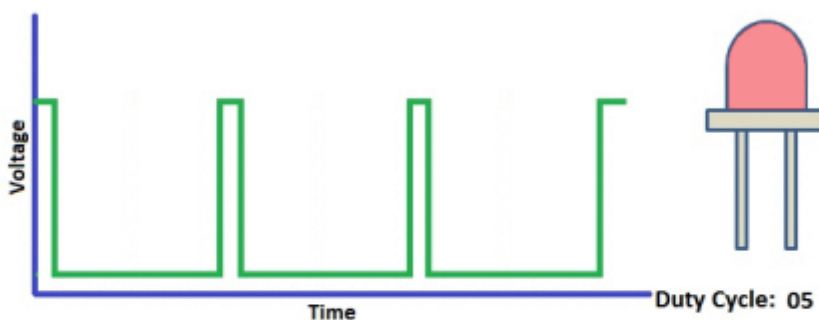

For the Arduino digital port voltage output, there are only LOW and HIGH, which correspond to the voltage output of 0V and 5V. You can define LOW as 0 and HIGH as 1, and let the Arduino output five hundred 0 or 1 signals within 1 second.

If output five hundred 1, that is 5V; if all of which is 1, that is 0V. If output 010101010101 in this way then the output port is 2.5V.
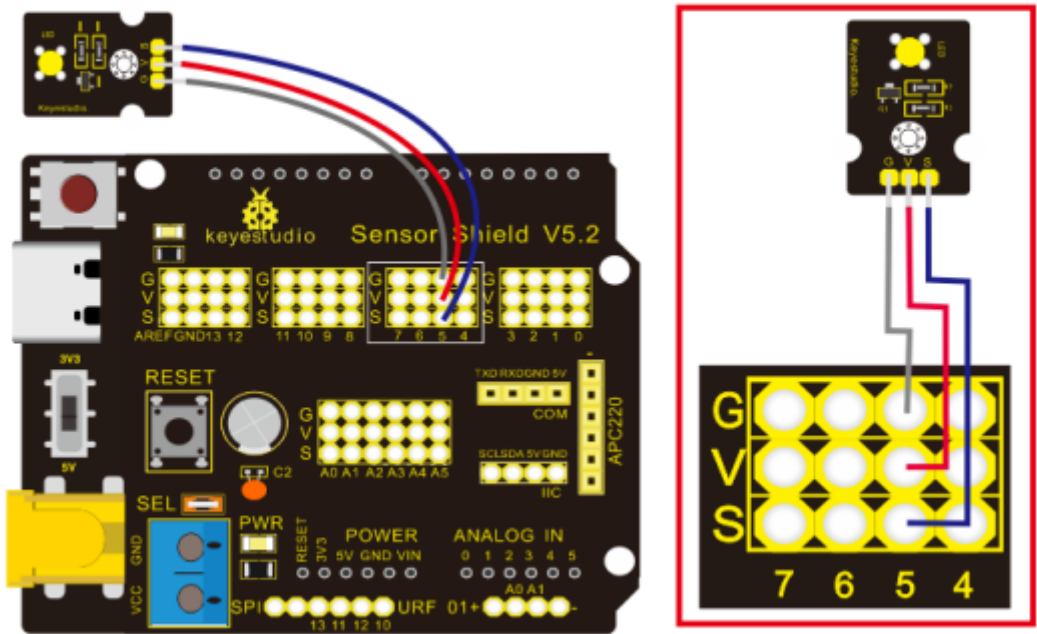
This is like showing movie. The movie we watch are not completely continuous. It actually outputs 25 pictures per second. In this case, the human can't tell it, neither does PWM.

If want different voltage, need to control the ratio of 0 and 1. The more 0 and 1 signals output per unit time, the more accurately control.

2. Needed Components

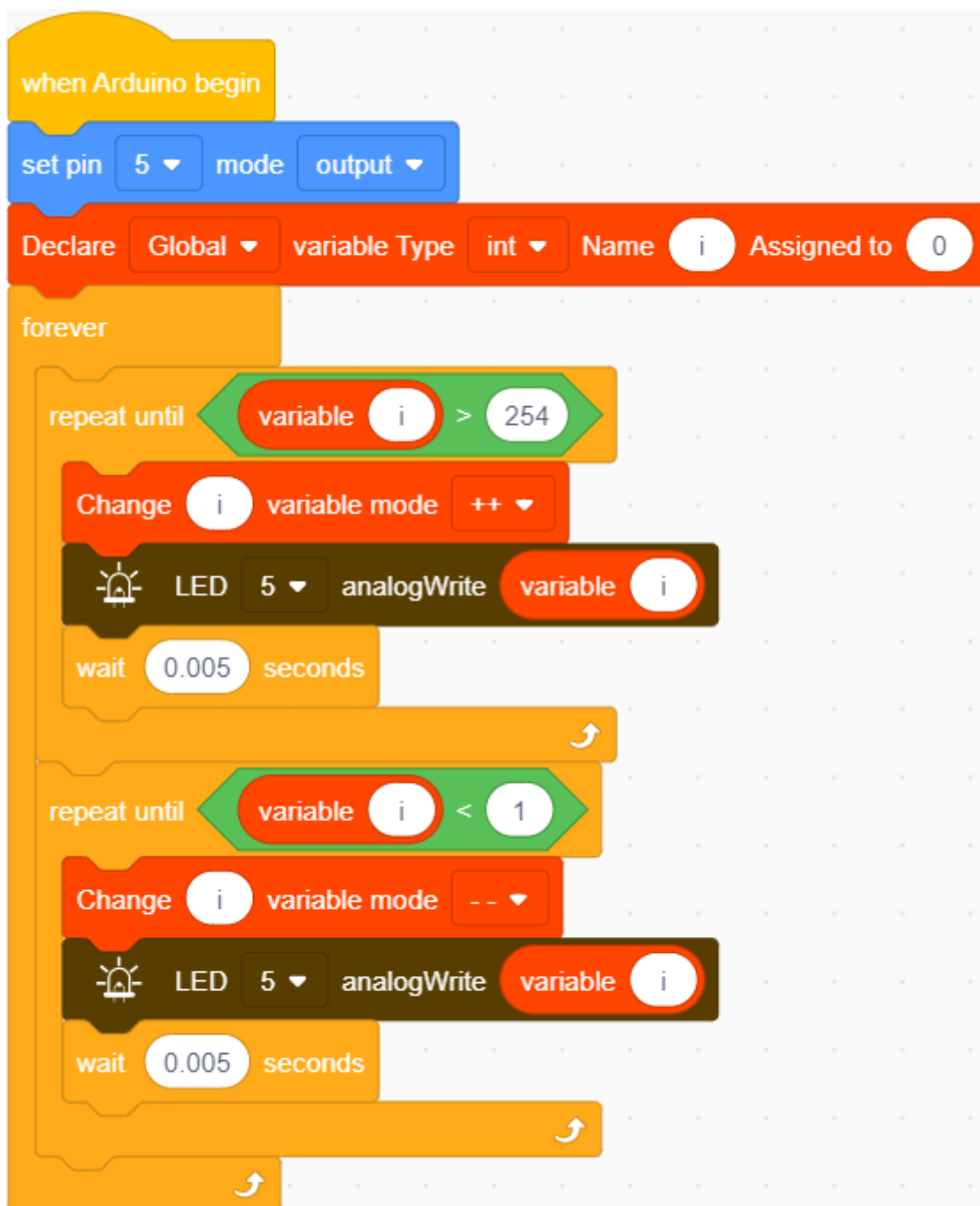| PLUS control board*1	Expansion board*1	Yellow LED*1	USB cable *1	3Pin F-F Dupont wire*1

3. Wiring Diagram

Note: The G, V and S pins of yellow LED are linked with G, V and 5.

4. Test Code

```
when Arduino begin
set pin  5 ▼  mode  output ▼
Declare  Global ▼  variable Type  int ▼  Name ( i )  Assigned to ( 0 )
forever
    repeat until  < variable ( i )  >  254 >
        Change ( i ) variable mode  ++ ▼
            LED  5 ▼  analogWrite  variable ( i )
        wait ( 0.005 ) seconds
    repeat until  < variable ( i )  <  1 >
        Change ( i ) variable mode  - - ▼
            LED  5 ▼  analogWrite  variable ( i )
        wait ( 0.005 ) seconds
```

5. Test Result

After the code is uploaded, LED smoothly changes its brightness in a circulation, which is similar to a lung breathing in and out.
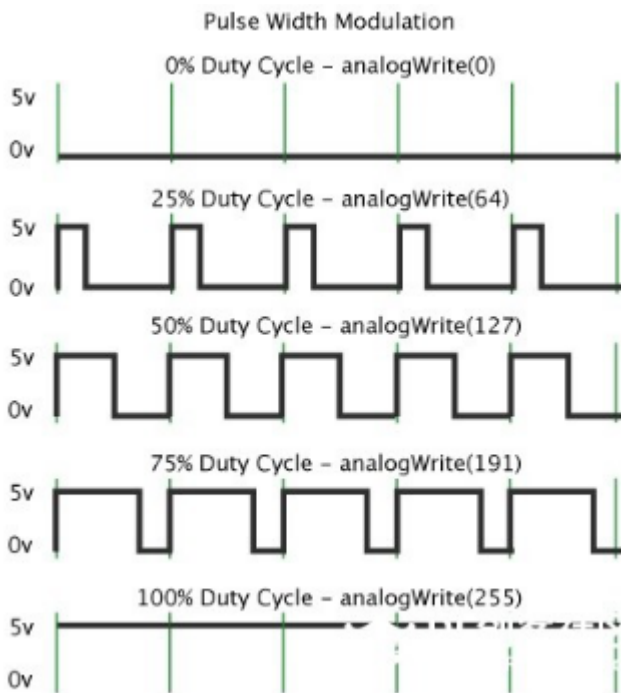
6. Relevent Knowledge

PWM is a tech of controlling the analog output via digital means. Digital control is used to generate square waves with different duty cycles (a signal that constantly switches between high and low levels).

By controlling duration ratio of LED on and off, the voltage of 0~5V can be simulated. The duration time (technically known as high level) is called Pulse Width.

And PWM is fully named Pulse Width Modulation. Here are five square waves of PWM.

Pulse Width Modulation

0% Duty Cycle – analogWrite(0)

25% Duty Cycle – analogWrite(64)

50% Duty Cycle – analogWrite(127)

75% Duty Cycle – analogWrite(191)

100% Duty Cycle – analogWrite(255)

Every green line saparates a period, and the value in analogWrite() should be a percentage technically known as duty cycle, which is calculated by the high duration divided by the low duration in a cycle.

The duty cycle of the first square wave equals 0%, whose value is 0 with the lowest LED birghtness(light-off state).

The longer the duration of high level is, the brighter LED will be.

Therefore, the last duty cycle equals 100%, whose value is 255 with the brightest LED.

In practice, PWM is mainly applied to adjust LED brightness and motor speed.