

EP1000

Digital I/O

Digital I/O



- The Uno uses the ATmega328 processor, which has 14 digital I/O pins (Some of these pins are multifunctional)
- A digital I/O pin can input or output digital (0, 5V) signals.

Digital I/O functions

- The Arduino system provides 3 functions for the manipulation of digital I/O.
- You need to
 1. Configure the pin (`pinMode()`), before
 2. Using the pin
 - `digitalWrite()` output
 - `digitalRead()` input

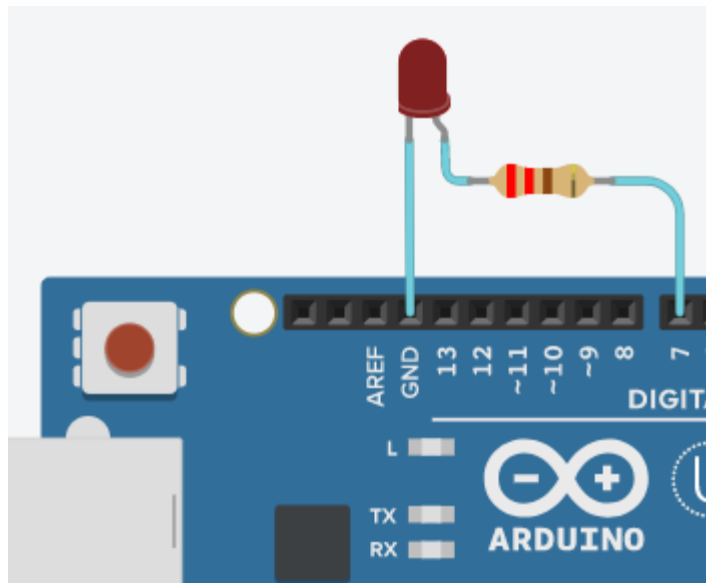
Digital I/O functions
<ul style="list-style-type: none">• <u><code>digitalRead()</code></u>• <u><code>digitalWrite()</code></u>• <u><code>pinMode()</code></u>

pinMode(pin, MODE)

- Configures specified pin to behave either as an input or an output.
- Modes available:
 - INPUT
digital input mode (high-impedance state)
 - INPUT_PULLUP
digital input mode with internal 20K~50K ohm pull-up resistor
 - OUTPUT
digital output mode able to source up to 40mA per pin, total of 200mA per chip

digitalWrite(pin, {LOW|HIGH})

- Outputs a LOW (0V) or HIGH (5V) to a digital pin.
- The digital pin must be configured as OUTPUT.



You can also output a LOW to create a GND for sinking current!

```

2
3 // Red LED connected to pin 7
4 #define RED 7
5
6 ...
7
8 // set as digital OUTPUT
9 pinMode(RED, OUTPUT);
10
11 // flash the LED
12 digitalWrite(RED, HIGH);
13 delay(300);
14 digitalWrite(RED, LOW);
15 delay(300);
16

```

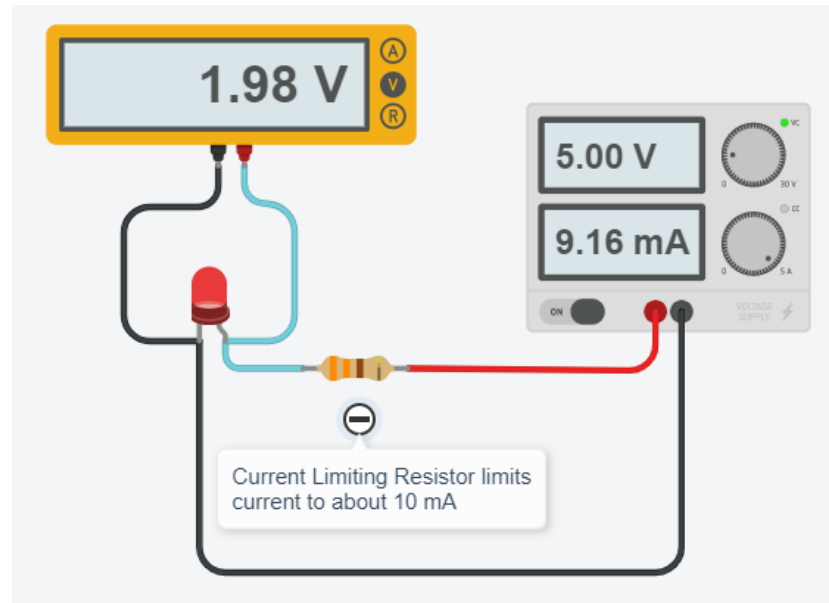
Driving an LED

- An LED lights up (conducts) if a correct voltage is applied to the pins.
- When the LED conducts, current is allowed to pass through. The LED drops about 2V.
- We need to limit this current (10~20mA) otherwise, we will get a short-circuit.
- Current limiting resistor value:

$$R = V / I$$

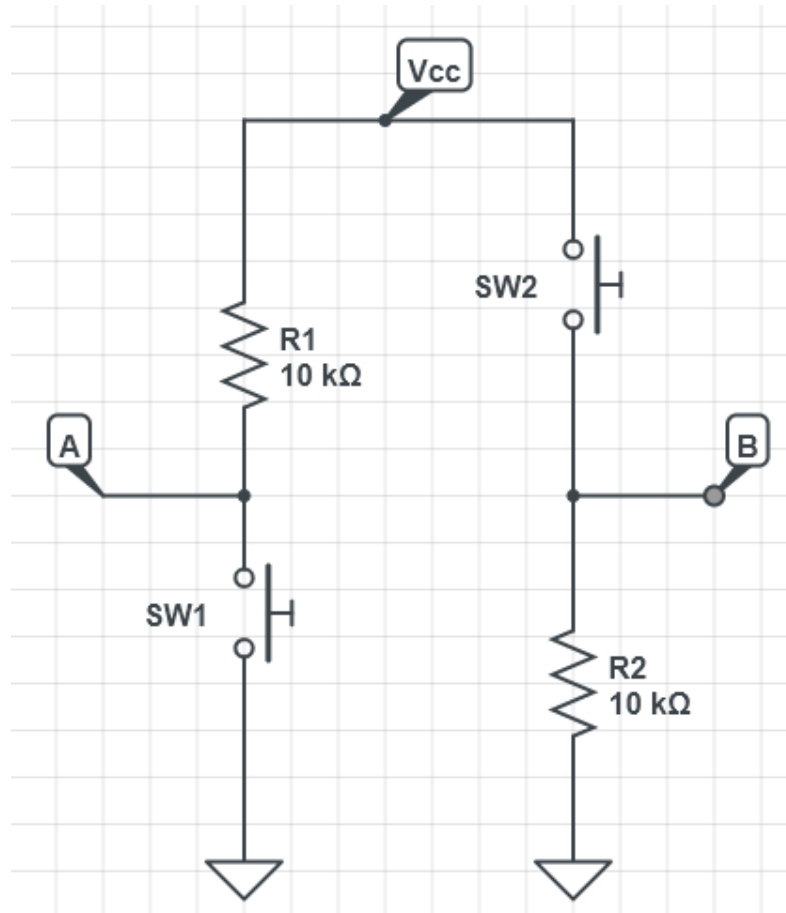
$$= (5 - 2V) / 10 \text{ mA}$$

$$= 300 \text{ ohms}$$



LED current depends on type, check [data sheet](#) for forward voltage and current limits.
 Watch: GreatScott! [Everything about LEDs](#)

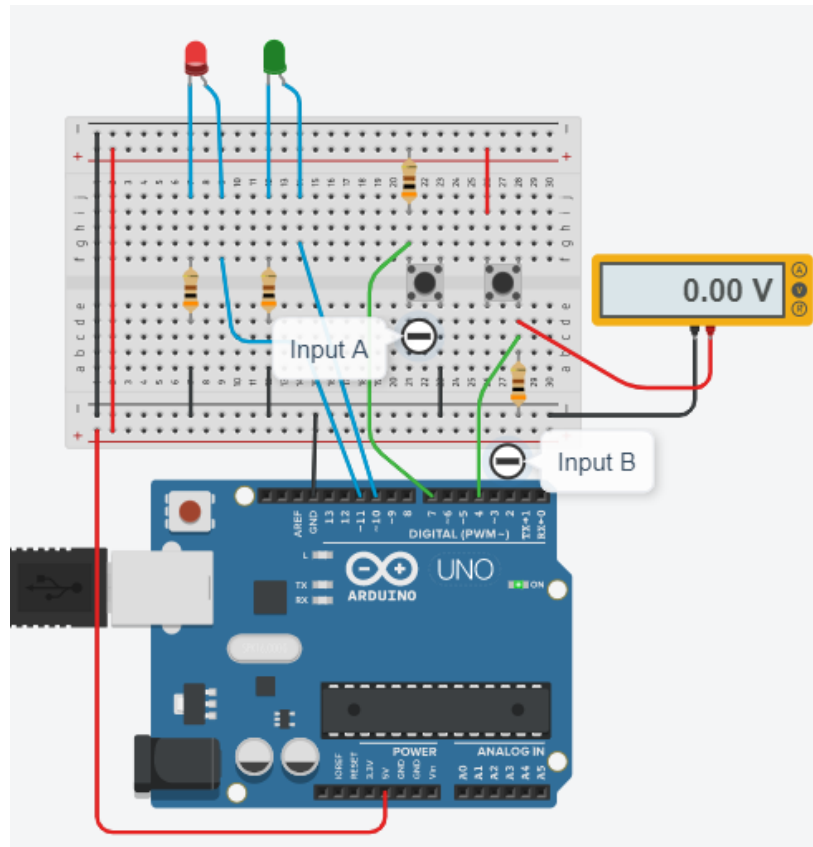
Digital Input



Circuits by [CircuitLab](https://circuitlab.com/)

- We can use digital inputs to read the status of the switches in a circuit.
- Need to add a current-limiting resistor to prevent short circuits.
- Usual value is 10 kΩ
- States:
 - A - normal HIGH, when closed LOW
 - B - normal LOW, when closed HIGH

Digital Input



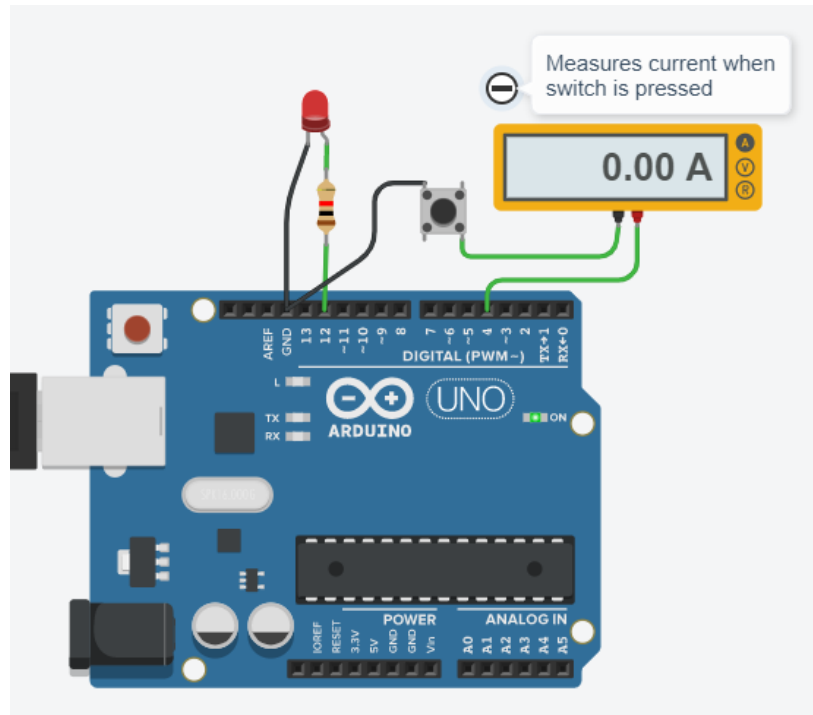
How to use PB switches with digitalRead()

```

2  #define RED 11
3  #define GREEN 10
4  #define A 7
5  #define B 4
6
7  void setup()
8  {
9      pinMode(RED, OUTPUT);
10     pinMode(GREEN, OUTPUT);
11     pinMode(A, INPUT);
12     pinMode(B, INPUT);
13 }
14
15 void loop()
16 {
17     if (digitalRead(A) == HIGH){
18         digitalWrite(RED, HIGH);
19     }
20     else{
21         digitalWrite(RED, LOW);
22     }
23     if (digitalRead(B) == LOW){
24         digitalWrite(GREEN, LOW);
25     }
26     else{
27         digitalWrite(GREEN, HIGH);
28     }
29 }
30

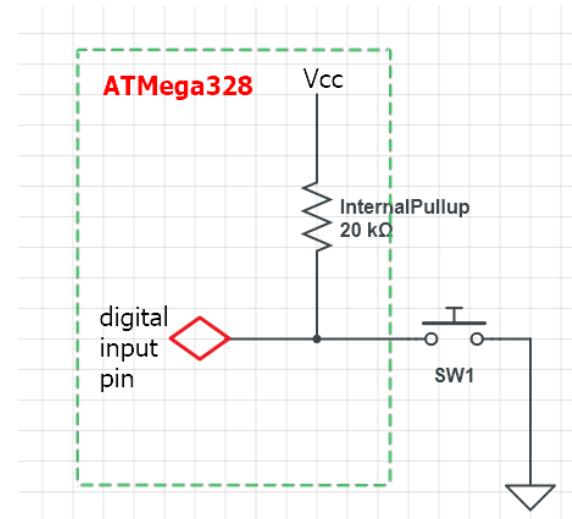
```


Internal Input Pullup Resistor

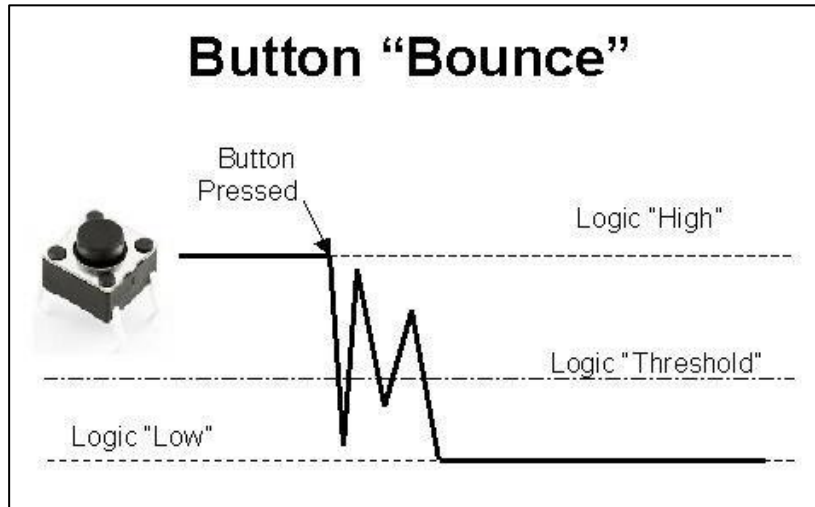


Uno input pullup resistor demo

- We can use the internal pullup resistor by changing the mode
- `pinMode(pin, INPUT_PULLUP)`
- Internal pullup resistor is 20K~50K which limits the current.



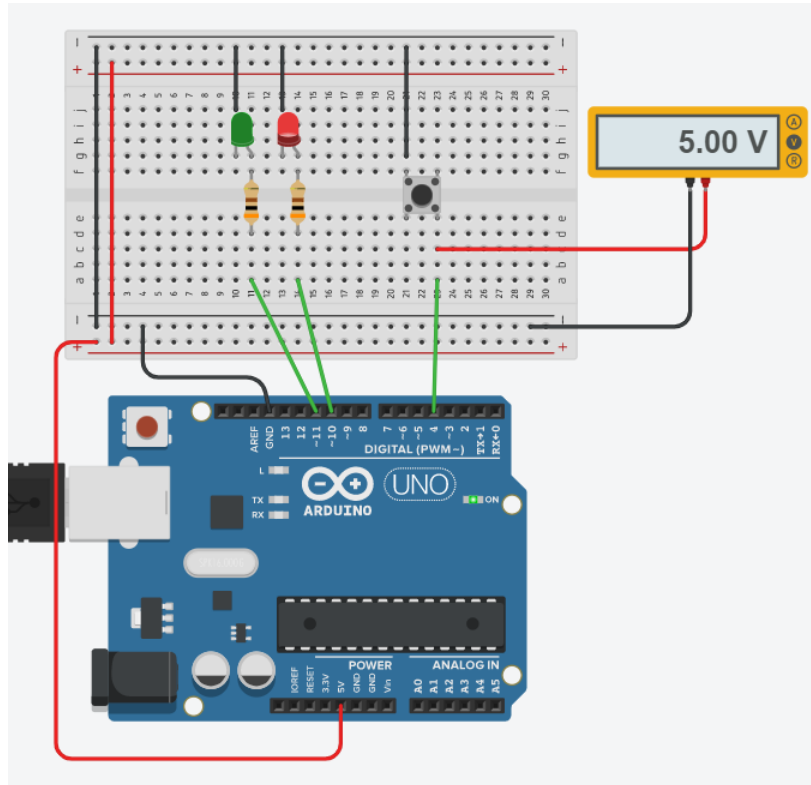
Problems with Mechanical Switches



[Software Debounce of buttons](#)

- When a mechanical switch is pressed, it creates transients (bouncing) which causes incorrect states to be read.
- Solution:
 - Software debounce
 - Add a delay
 - Use states

Counting with a Switch



Counting With a Switch

- PB SW uses internal pullup resistor.
- Each time the switch is pressed, the count is incremented. The LEDs should show the binary equivalent of the count
- Sequence:
-- , -R , G- , GR
repeats
- Simulate and examine result, does it work as stipulated?

Code: Counting with a switch

```
1
2 #define RED    10
3 #define GREEN  11
4 #define PBSW   4
5
6 int count = 0; // initial count value
7
8 void setup()
9 {
10  pinMode(REDF, OUTPUT);
11  pinMode(GREEN, OUTPUT);
12  pinMode(PBSW, INPUT_PULLUP);
13  decode(count);
14 }
15
16 void loop()
17 {
18  if (digitalRead(PBSW) == LOW){
19    // switch was pressed
20    count = (count + 1) % 4; // only 4 states
21    decode(count); // display it
22  }
23 }
24
```

How do we debug this code?

```
25 // decodes count into binary
26 void decode(int v)
27 {
28   switch(v){
29     case 0:
30       digitalWrite(REDF, 0);
31       digitalWrite(GREEN, 0);
32       break;
33     case 1:
34       digitalWrite(REDF, 1);
35       digitalWrite(GREEN, 0);
36       break;
37     case 2:
38       digitalWrite(REDF, 0);
39       digitalWrite(GREEN, 1);
40       break;
41     case 3:
42       digitalWrite(REDF, 1);
43       digitalWrite(GREEN, 1);
44       break;
45   }
46 }
```

Arduino Serial Mode

- The Arduino System provides a Serial Mode for displaying text messages.
- Uses the Uno's serial port to transmit data to and from the board to the IDE
- Allows data to be displayed in text as well as in graphical format.
- Uses the Arduino Built-in library: [Serial](#)
- When using Serial, you must **not** use the Tx,Rx pins for any I/O.

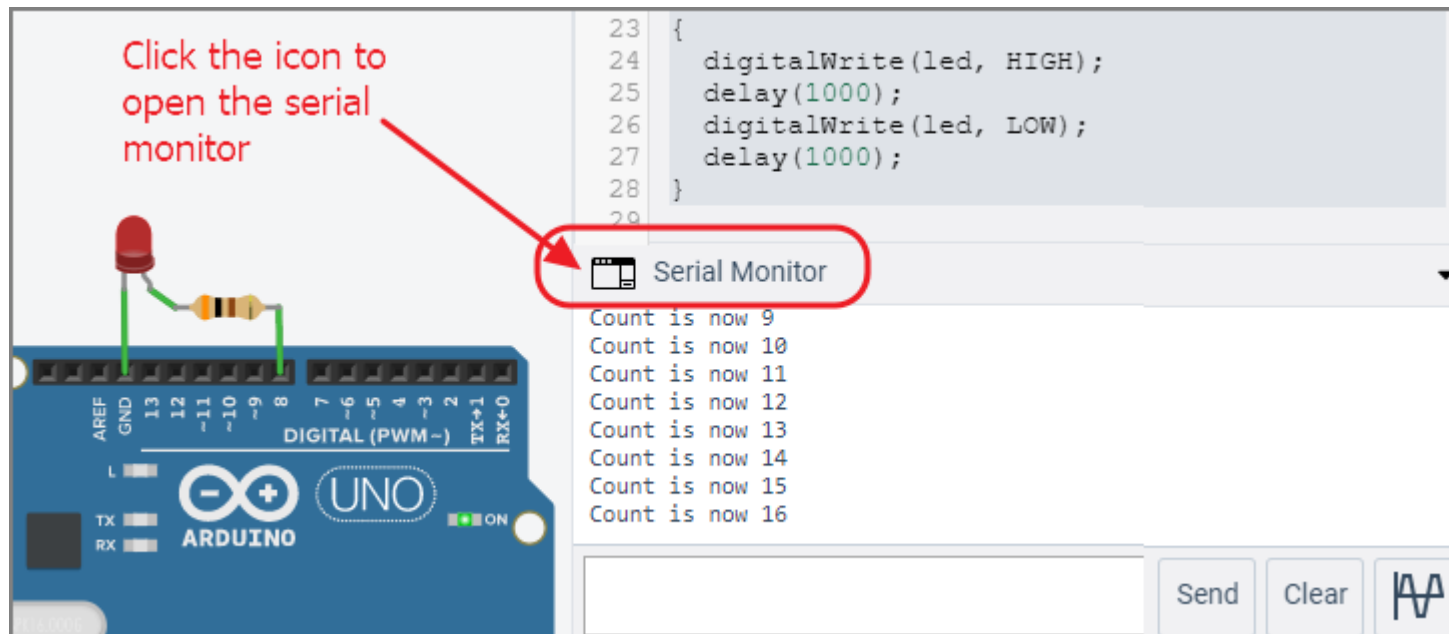
Serial Library

```
2
3  #define LED 8
4  int count = 0;
5
6  void setup()
7  {
8      // initialise TxRx speed
9      Serial.begin(9600);
10     pinMode(LED, OUTPUT);
11 }
12
13 void loop()
14 {
15     // send msg to Serial port
16     Serial.print("Count is now ");
17     Serial.println(count);
18     flash(LED);
19     count = count + 1;
20 }
21
22 void flash(int led)
23 {
24     digitalWrite(led, HIGH);
25     delay(1000);
26     digitalWrite(led, LOW);
27     delay(1000);
28 }
29
```

- Use Serial to display the count value from a sketch. The sketch updates the count value and flashes an LED with a delay of 1 second between flashes.
- [Serial.begin\(9600\)](#)
Sets the data rate in bits/sec for serial data transmission
- [Serial.print\(data\)](#)
[Serial.println\(data\)](#)
Sends data to the serial port for conversion and output. If a string of text is sent, it must be delimited with double quotes ("")
- There are other functions, but usually not used in embedded circuits.

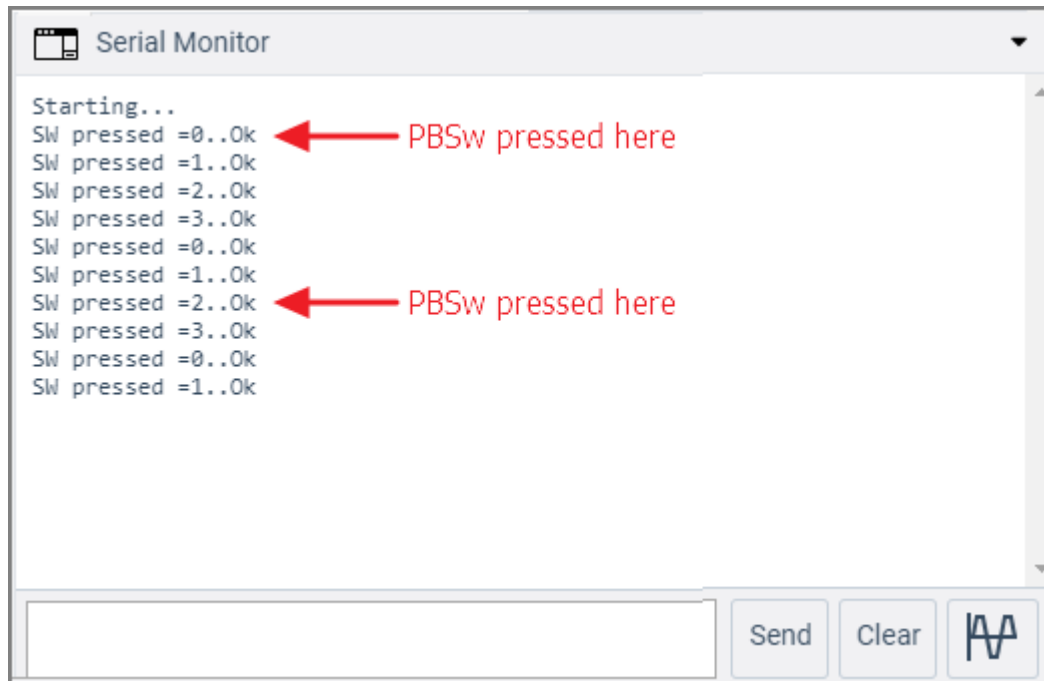
Where does the serial output go?

- There is an icon/text “Serial Monitor” on both the TinkerCAD and Arduino IDE interface to show the contents of the serial monitor.
- You can clear, input and output data as well as graphically chart the data you receive from the embedded system.



[Using the Serial Monitor](#)

Debug our Counting SW program



[Debugging the SW counting program](#)

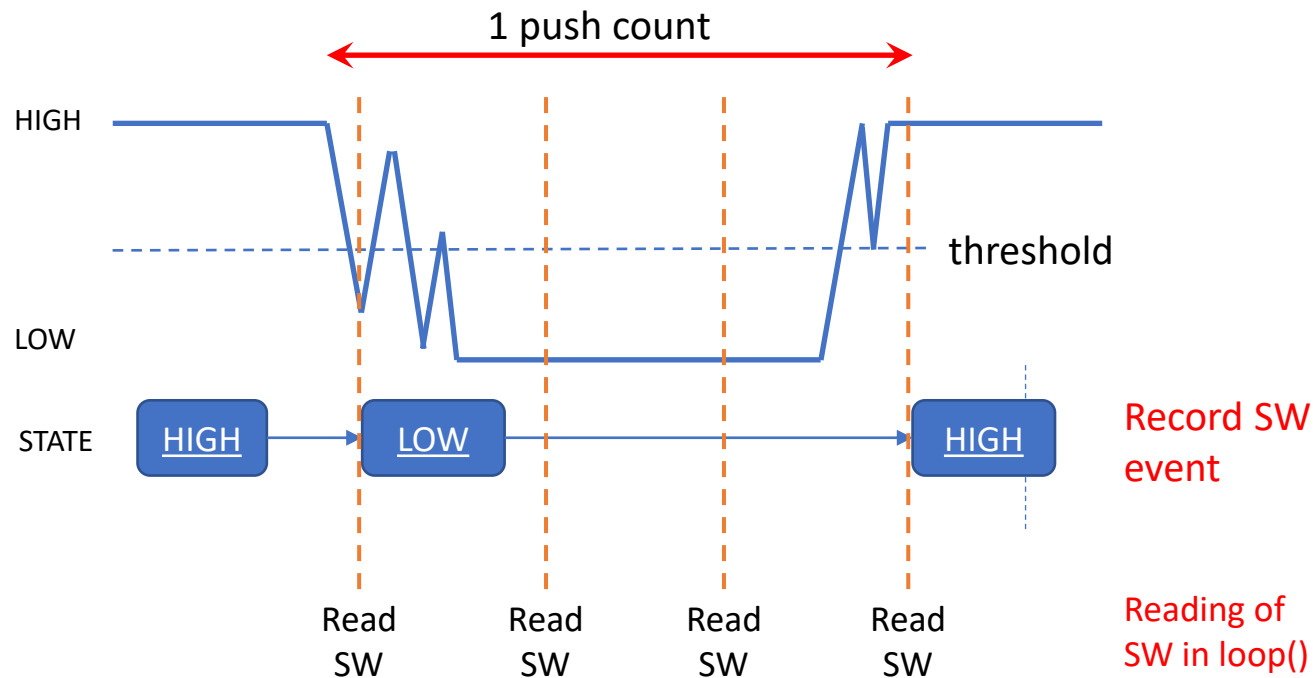
```

3 void setup()
4 {
5     ...
6     Serial.begin(9600);
7     Serial.println("Starting...");
8 }
9
10 void loop()
11 {
12     if (digitalRead(PBSW) == LOW){
13         // switch was pressed
14         Serial.print("SW pressed =");
15         Serial.print(count);
16         count = (count + 1) % 4;
17         decode(count); // display it
18         Serial.println("..0k");
19     }
20 }

```

- Looks like we have bouncing problem and/or the switch is being read too fast (SW not recovered yet)

Pushbutton SW



- We keep reading the PBSW taking note of the PBswitch value
- We maintain the state so that we know which part of the sequence we are currently in and when the PBSW returns to normal
- Register the entire sequence as a single push.

Using states

- Use states to track the keypress.
- HIGH = normal
LOW = in a keypress
HIGH = returns to normal
- Add short delay when key is pressed to remove bouncing
- Record the keypress only when the sequence is complete.

```
2
3 void loop()
4 {
5     if(digitalRead(PBSW) == LOW){
6         // switch pressed
7         if (state == HIGH){
8             // ok, Lets process
9             state = LOW;
10        }
11        else {
12            // ignore, since state = LOW
13        }
14    }
15    else {
16        // switch is at normal
17        if (state == LOW){
18            // register keypress
19            count = (count + 1) % 4;
20            decode(count);
21            state = HIGH;
22        }
23    }
24 }
25
```

Reading a Pushbutton using states

- Serial Monitor output



Assignment: Programming

- Work out [Assignment 12 Introduction to Arduino Programming](#) using TinkerCAD.
- Simulate your solution using TinkerCAD.
Use Serial to display messages showing the states and to show that you know how to use the library and the serial monitor.
- Document your work on your site.

This method is often used in projects. It uses a single Pushbutton Switch to control different functions.

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Digital I/O

End