ELEC1601

Introduction to Computer Systems

Week 2. Loops, Polling, Interrupts and Introduction to binary

The University of Sydney

Outline:

- Lab review
- Polling vs interrupts
- Introduction to binary

Polling

- Continual checking of a status of a device.
- In the labs we are polling the status of a PIN
- Requires a loop.

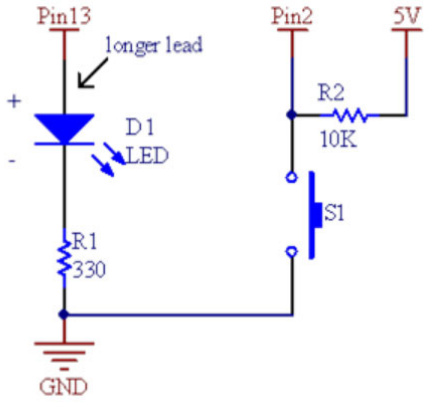
Polling

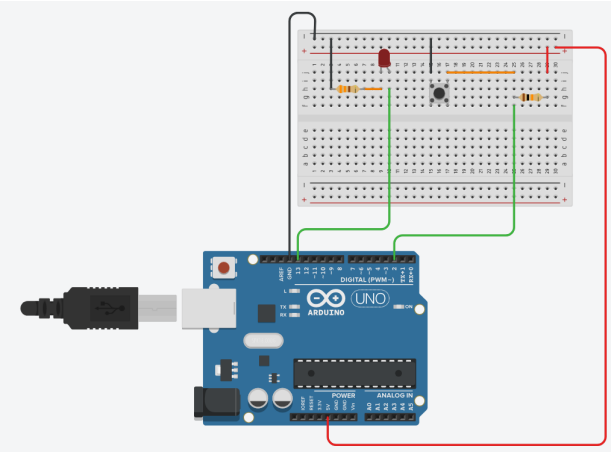
- How do we choose a delay?
- What happens if we choose a quick delay?
- What happens if we choose a long delay?

Polling – Example. Light = button

```
// C++ code
//
int past;

void setup()
{
     pinMode(13, OUTPUT);
     pinMode(2, INPUT);

     Serial.begin(9600);
}

//v1
void loop()
{
    int button = digitalRead(2);
    digitalWrite(13, button);
    delay(200); // Pause

    /*
    if (button == HIGH)
    {
        Serial.println("Button is 0");
    }
    else
    {
        Serial.println("Button is 1");
    }

    if (button != past)
        Serial.println("changed");
    else
        Serial.println("not changed");

    past = button;
    */

}
```

- What happens if we choose a quick delay?
- What happens if we choose a long delay?





Polling – Example. Light change = full button press

```
// C++ code
//

boolean light_on;
boolean prev_button;

void setup()
{
  pinMode(13, OUTPUT);
  pinMode(2, INPUT);
  prev_button = false;
  light_on = false;
  Serial.begin(9600);
}

//v1
void loop()
{

    Serial.println("Polling Loop started");
    int button = digitalRead(2);

    if (button != prev_button)
    {
      Serial.println("Button changed (pushed down)");
      prev_button = button;
      if (button == HIGH) {
        Serial.println("Button press finished. Toggle light");
        light_on = !light_on; //toggle light_on variable
        digitalWrite(13, light_on);
      }

    }

    // Pause for 1 second
    delay(2000);
}
```

- What happens if we choose a quick delay?
- What happens if we choose a long delay?

- In hardware no delay can lead to an error.
  - How?

Interrupt

- Hardware mechanism notifying CPU it needs attention.
- Serviced by an Interrupt Service Routine

Interrupts – Light = button

```
// C++ code
//

void setup()
{
     pinMode(10, OUTPUT);
     pinMode(2, INPUT);

     Serial.begin(9600);
     attachInterrupt(0, changeLED, CHANGE);
}

//v2

void changeLED()
{

    int button = digitalRead(2);
    if (button == LOW)
    {
        Serial.println("Button is 0");
        digitalWrite(10, false);
    }
    else
    {
        Serial.println("Button is 1");
        digitalWrite(10, true);
    }

}
void loop()
{
    Serial.println("Loop started");
    // Pause for 1 second
    delay(2000);
}
```

– How quick is the response time?

Interrupt – Example. Light change = full button press

```
// C++ code
//

//v3
boolean interruptFired;
boolean light_on;
byte interrupt_count;
void setup()
{
    Serial.begin(9600);
    attachInterrupt(0, changeLED, CHANGE);
    pinMode(10, OUTPUT);
    pinMode(2, INPUT);
    light_on = 0;
}

void changeLED()
{
    light_on = !(light_on);
    Serial.println("Button Pressed");
    Serial.println(light_on);
    digitalWrite(10, light_on);

}
void loop()
{
    Serial.println("Loop started");
    // Pause for 1 second
    delay(2000);
}
```

– What goes wrong

Interrupt

- Hardware mechanism notifying CPU it needs attention.
- Serviced by an Interrupt Service Routine
- What happens if you issue an interrupt while you have an interrupt?

Interrupt

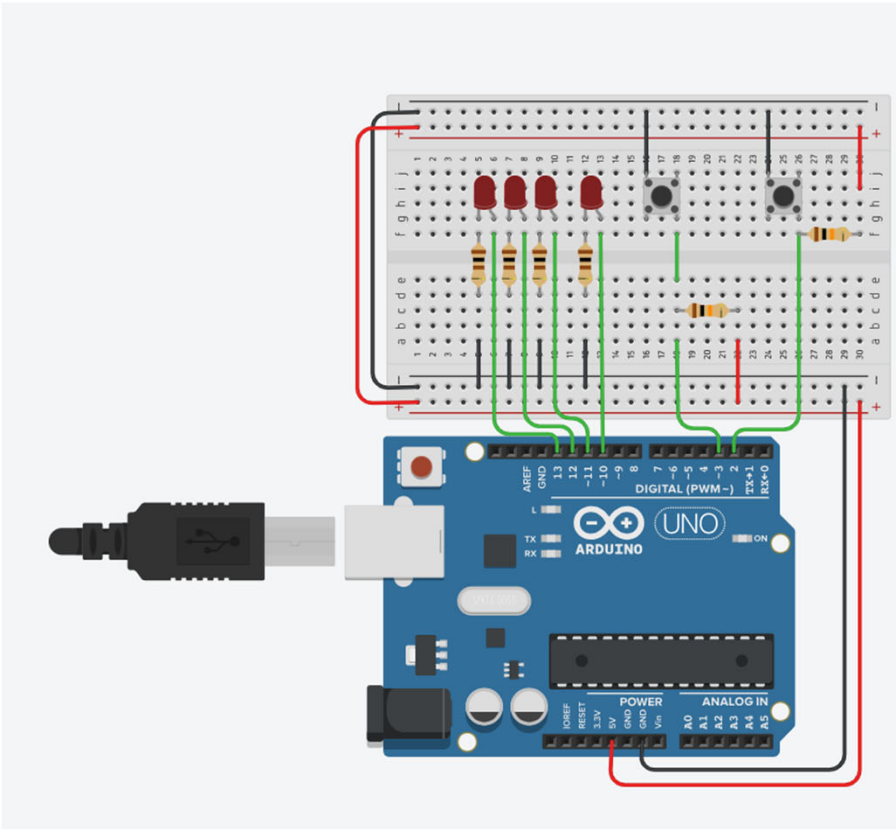
- **Hardware mechanism notifying CPU it needs attention.**
- **Serviced by an Interrupt Service Routine**
- **What happens if you issue an interrupt while you have an interrupt**
  - 33023ABook (microchip.com)
  - How can you minimise the odds of this occurring?

Interrupt – Short ISR. Light change = full button press

```
// C++ code
//

//v3
boolean interruptFired;
boolean light_on;
byte interrupt_count;
void setup()
{
    Serial.begin(9600);
    attachInterrupt(0, interruptServiceRoutine, FALLING);
    pinMode(10, OUTPUT);
    pinMode(2, INPUT);
    interruptFired = false;
    interrupt_count = 0;
}


//v3
void loop()
{

    delay(2000);

    if (interruptFired)
    {
        interruptFired = false;
        Serial.println("Interrupt fired in the last 2000ms.");
        if (light_on == false) {
          light_on = true;
        }
        else {
          light_on = false;
        }
        digitalWrite(10, light_on);
        Serial.print("Current Interrupts:");
        Serial.println(interrupt_count);
    }

}

void interruptServiceRoutine()
{
    interruptFired = true;
    interrupt_count++;
}
```

- Is this just polling?
- Can interrupts be missed?

Lab 1 Part 4



Text

1 (Arduino Uno R3)

```
// C++ code
//

//v3
boolean interruptFired;
boolean resetInterruptFired;
boolean light_on;
const byte interruptPin2 = 2;
const byte interruptPin3 = 3;
int counter;

void setup()
{
    Serial.begin(9600);
    pinMode(interruptPin2, INPUT);
    attachInterrupt(digitalPinToInterrupt(interruptPin2), ISR1, FALLING);
    pinMode(interruptPin3, INPUT);
    attachInterrupt(digitalPinToInterrupt(interruptPin3), ISR2, FALLING);

    pinMode(10, OUTPUT);
    pinMode(11, OUTPUT);
    pinMode(12, OUTPUT);
    pinMode(13, OUTPUT);
    interruptFired = false;
    counter=0;
    light_on = 0;
}

//v3
void loop()
{

    delay(1000);
    if (interruptFired)
    {
        interruptFired = false;
        counter++;
        Serial.print("Current Count ");
        Serial.print(counter);
        Serial.println(";");
    }
    if (resetInterruptFired)
    {
        resetInterruptFired = false;
        counter=0;
    }
    if (counter>4)
    {
      light_on = !light_on;
      digitalWrite(10, light_on);
      digitalWrite(11, light_on);
      digitalWrite(12, light_on);
      digitalWrite(13, light_on);
    }
    else
    {
      digitalWrite(10, (counter>0));
      digitalWrite(11, (counter>1));
      digitalWrite(12, (counter>2));
      digitalWrite(13, (counter>3));
    }
}
```

Introduction to binary

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How do we count natural numbers $\mathbb{N}$ in radix-10(or base 10)?

How do we interpret numbers in radix-10(or base 10)?

- Consider the number 429_{10}
- How do we break it down?

How do we count natural numbers $\mathbb{N}$ in radix-2(binary)?

How do we interpret numbers in radix-2(binary)?

- Consider the number 111010_2 mean
- How do we break it down?

How do we add natural numbers $\mathbb{N}$ in radix-10(or base 10)?

How do we add natural numbers $\mathbb{N}$ in radix-2(binary)?

What is Two's complement

- Same as unsigned binary
- Most significant digit has a negative weight

What happens if we add two's complement numbers?

Two's complement – the quick conversion trick

- Same as unsigned binary
- Most significant digit has a negative weight

Two's complement

- Consider the two's complement number 111010_2
- How do we break it down?

Two's complement – example addition

- **Compute 28+(-26) in two's complement**

Two's complement – example subtraction

- **Compute 29-23 in two's complement**

How do we represent numbers between 1 and 0 in binary?

How do we represent numbers between 1 and 0 in binary?