Embedded System Design with MCU and FPGA

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Goal

Let us know more about GPIO, Timer, and Clock.

Problems

1. Describe at least two methods that you used to blink the LED.

- There are three methods which could be used to blink the LED.

① **Waiting**

- Use delay() function, such as Fig 1., to blink the LED. (Here is the link of the experiment.)
- **delay()** is a blocking function.

```
1  void setup() {
2    DDRB |= (1 << 5);
3  }
4
5  void loop() {
6    PORTB |= (1<<5);
7    delay(1000);
8    PORTB &= ~(1<<5);
9    delay(1000);
10 }
```

Fig 1. using delay() to blink LED

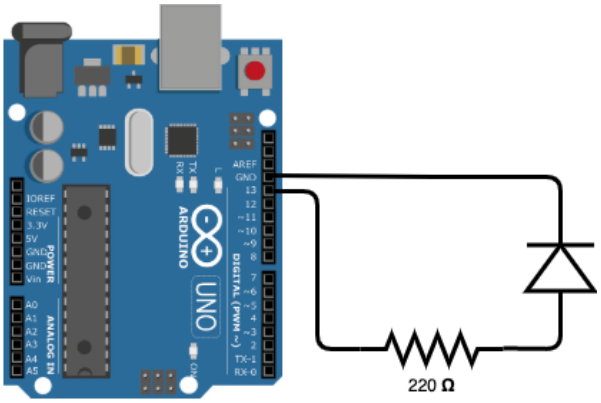


Fig 2. circuit diagram of blink LED

- Use **millis()** function, such as Fig 3., to blink the LED.

② **Interrupt**

- Use a **timer**, such as Fig 4., to blink the LED. (Here is the link of the experiment.)

```
1  const int ledPin = 13;
2  int ledState = LOW;
3  unsigned long previousMillis = 0;
4  const int interval = 1000;
5
6  void setup() {
7    pinMode(ledPin, OUTPUT);
8  }
9
10 void loop() {
11   unsigned long currentMillis = millis();
12   if (currentMillis - previousMillis > interval) {
13     previousMillis = currentMillis;
14     ledState = !ledState;
15     digitalWrite(ledPin, ledState);
16   }
17 }
```

Fig 3. using millis() to blink the LED

```
1  const int ledPin = 13;
2  void setup() {
3    pinMode(ledPin, OUTPUT);
4    TCCR1A = 0x00;
5    TCCR1B |= _BV(CS12);
6    TCCR1B &= ~_BV(CS11);
7    TCCR1B |= _BV(CS10);
8    TCNT1 = 0;
9  }
10
11 void loop() {
12   digitalWrite(ledPin, HIGH);
13   delay1s();
14   digitalWrite(ledPin, LOW);
15   delay1s();
16 }
17
18 void delay1s() {
19   while (TCNT1 < 15625/2)
20   ;
21   TCNT1 = 0;
22 }
```

Fig 4. using timer to blink the LED

- Use an **external interrupt wired** to an external source that toggles a logic state each second. (Any clock should be a good source.)

③ **Polling**

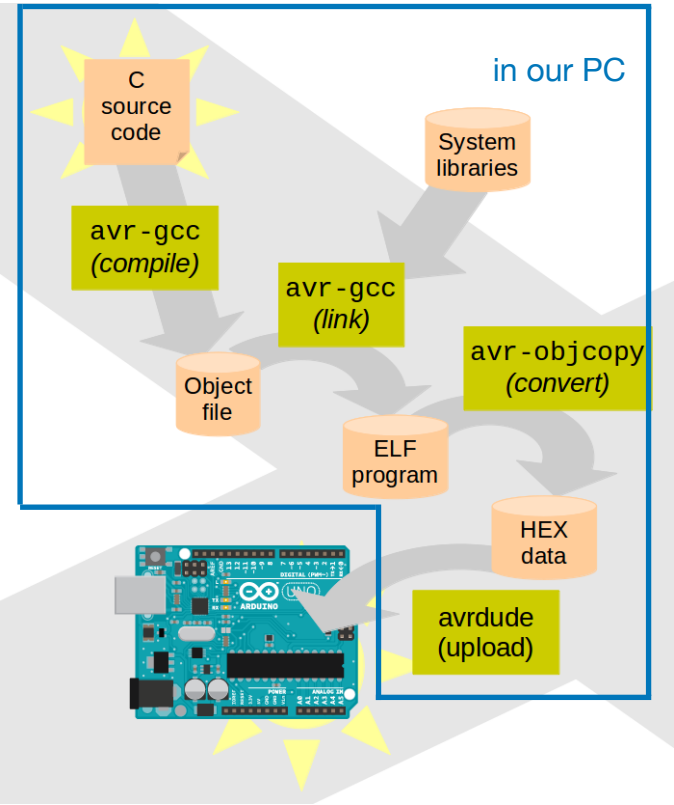
- Use a **library** like TimedAction, EventFuse, Scheduler or simply 'Blink without delay'

2. How many timer in ATmega 328p? What is the usage of timer0 in Arduino world.

- There are **three timer registers** in ATmega 328p. [3]
  - two 8-bit timers which are **timer0** and **timer2**
  - one 16-bit timers which is **timer1**
  - The most important difference between 8-bit and 16-bit timer is the timer resolution. 8bits means 256 values where 16bit means 65536 values.
- In the Arduino world, the usage of each timer:
  - timer0 is been used for the **timer functions, like delay(), millis() and micros()**
  - timer1 is been used in the Servo library
  - timer2 is been used in the tone() function

3. Explain why we should use the cross-compiler.

- A cross compiler is for cross-platform software development of machine code. [1]
- In the Arduino, direct compilation is infeasible, because it **doesn't contain operating system**. We could use the cross-compiler to compile the code on our computer, and generate the executable machine code for Arduino.



4. Explain your plan of de-bouncing the push button.

- Use **millis() function** to de-bounce the push button. (Here is the link of the experiment.)
- In Fig 6., it is the flow chart I used to de-bounce the push button.

```ino
const int buttonPin = 2;
const int ledPin = 13;
int ledState = HIGH;
int buttonState;
int lastButtonState = LOW;

unsigned long lastDebounceTime = 0;
unsigned long debounceDelay = 50;

void setup() {
  pinMode(buttonPin, INPUT);
  pinMode(ledPin, OUTPUT);
  digitalWrite(ledPin, ledState);
}

void loop() {
  int reading = digitalRead(buttonPin);
  if (reading != lastButtonState) {
    lastDebounceTime = millis();
  }
  if ((millis() - lastDebounceTime) > debounceDelay) {
    if (reading != buttonState) {
      buttonState = reading;
      if (buttonState == HIGH) {
        ledState = !ledState;
      }
    }
  }
  digitalWrite(ledPin, ledState);
  lastButtonState = reading;
}
```

Fig 5. using millis() to de-bounce the push

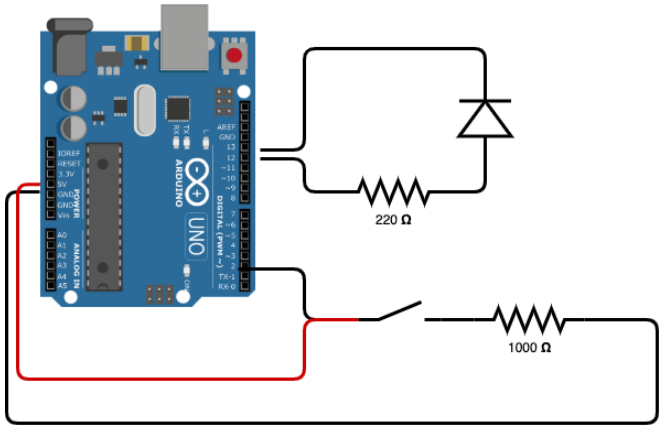


Fig 7. circuit diagram of de-bouncing the

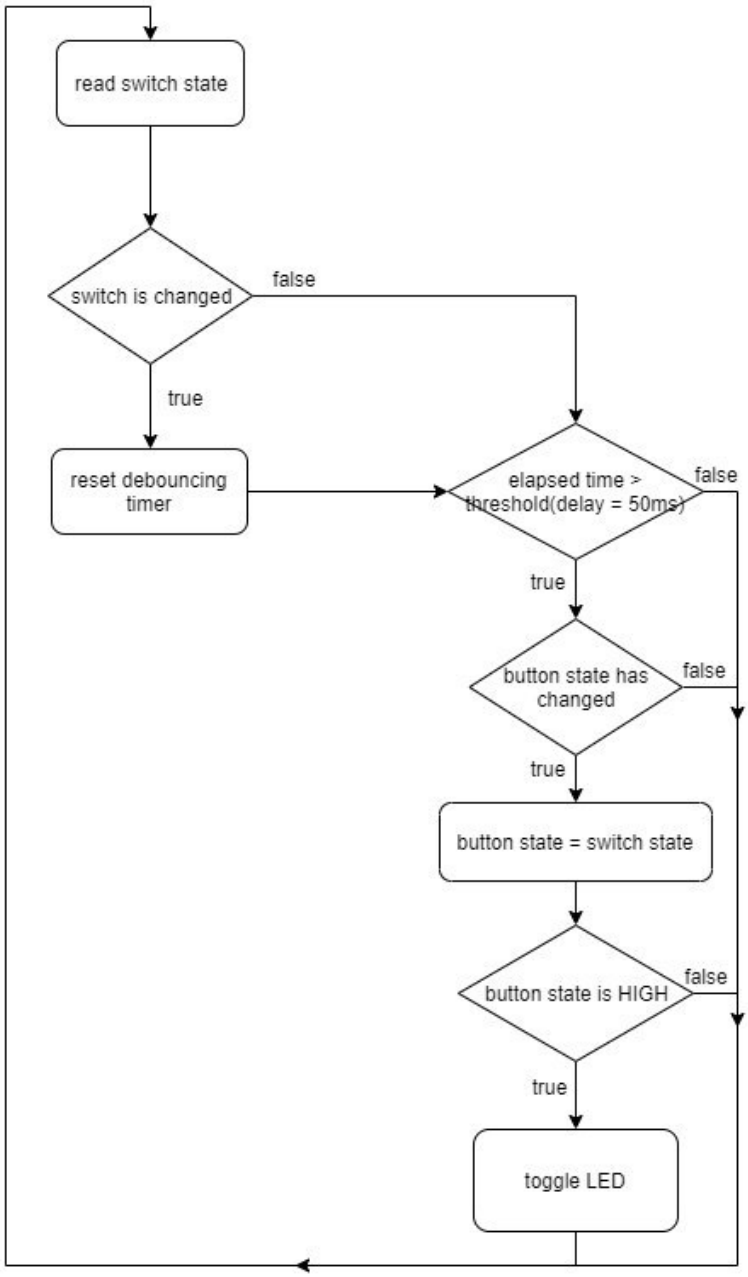


Fig 6. flow chart of de-bouncing the push button

Reference

[1] https://en.wikipedia.org/wiki/Cross_compiler

[2] http://www.avrbeginners.net/architecture/timers/timers.html

[3] https://www.arnabkumardas.com/online-courses/avr-timer-counter-programming-tutorial-atmega328p-avr-8-bit-arduino-uno/

* Note: The LAB exercises and answers in this report are discussed with another student 吳承霖(0858615).