# Example 1

Determine the outputs of the program and correct the program if there are any errors. Assume that a green color LED is connected to pin 5 and the clock frequency of the Arduino is 16 MHz. Compute the number of counts required for a 3 ms delay in each cycle for the given delay. Compute the number of times the while_true loop will run to execute the delays of LED ON time of 5 s and LED OFF time of 4 s. Use a pre-scaler value of 1024.

```
#define GREEN_PIN 10
int green_on = 5000;
int green_off = 4000;

int delay_timer (int final_count){
    int count = 0;
    while(1) {
       if (TCNT1 >= _____) {
          TCNT1=0;
          count++;
          if (count == final_count){
             count=0;
             break; }
       }
    }
    return 0;
}
```

```
void loop() {
   pinMode(GREEN_PIN, INPUT);
   TCCR0A = 0b00000000;
   TCCR0B = 0b00000100;
   TCNT1 = 0x0000;
}

void loop() {
   digitalWrite(BLUE_PIN, HIGH);
   delay(green_on);

   digitalRead(GREEN_PIN, LOW);
   delay_timer(blue_off);
}
```

Prescaler values and corresponding bits of TCCRxB

| CSx2 | CSx1 | CSx0 | Prescaler |
|---|---|---|---|
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 8 |
| 0 | 1 | 1 | 64 |
| 1 | 0 | 0 | 256 |
| 1 | 0 | 1 | 1024 |

# Solution of Example 1

System Clock frequency, $f_{sys\_clk}$ = 16 MHz = 16 x $10^6$ Hz;

Timer Clock frequency, $f_{timer\_clk} = f_{sys\_clk}$ /1024 = 16 x $10^6$ Hz/1024 = 15625 Hz;

Timer Clock Period, $T_{timer\_clk} = 1/ f_{timer\_clk} = 1/(15625\ Hz) = 64 \times 10^{-6}$ s

Required Delay = 3 ms = 3 x $10^{-3}$ s

$$\text{Timer count} = \frac{\text{Required delay}}{\text{Timer Clock Period}} - 1 = \frac{3 \text{ x } 10{-}3 \text{ s}}{64 \text{ x } 10{-}6 \text{ s}} - 1 = 46$$

Timer0 and Timer2 can count up to 255, whereas Timer1 can count up to 65,535; therefore, any Timer is suitable for this application.

The number of counts required in each cycle for the LED ON time of 5 s (5000 ms) = 5000 ms/3 ms = 1667.
The number of counts required in each cycle for the LED OFF time of 4 s (4000 ms) = 4000 ms/3 ms = 1334.

The output of the program is:
After correcting the program, the green LED connected to pin 5 will be turned ON for 5 s and OFF for 4 s and this ON-OFF status will be repeated indefinitely until the microcontroller's power is turned OFF.

# Solution of Example 1 (Contd…)

## The program after correction:

```
#define GREEN_PIN 5
int green_on = 1667;
int green_off = 1334;

int delay_timer (int final_count){
    int count = 0;
    while(1) {
       if (TCNT1 >=  46) {
          TCNT1=0;
          count++;
          if (count == final_count){
             count=0;
             break; }
       }
     }
    return 0;
}
```

```
void setup() {
   pinMode(GREEN_PIN, OUTPUT);
   TCCR1A = 0b00000000;
   TCCR1B = 0b00000101;
   TCNT1 = 0x0000;
}

void loop() {
   digitalWrite(GREEN_PIN, HIGH);
   delay_timer(green_on);

   digitalWrite(GREEN_PIN, LOW);
   delay_timer(green_off);
}
```

# Example 2

**You have to make an LED of red color blink every 4 seconds while using any of the three timers of ATmega328P microcontroller. The use of the built-in function delay() is prohibited. Decide which timer (Timer0/Timer1/Timer2) of the ATmega328P is suitable for your application. You may use a pre-scaler value of 8/64/256/1024. The system clock frequency of the ATmega328P microcontroller is 16 MHz. Write the necessary register set-up required for the program.**

# Solution of Example 2

System Clock frequency, $f_{sys\_clk}$ = 16 MHz = 16 x $10^6$ Hz;

Assuming a prescaler value of 1024,

Timer Clock frequency, $f_{timer\_clk} = f_{sys\_clk}$ /1024 = 16 x $10^6$ Hz/1024 = 15625 Hz;

Timer Clock Period, $T_{timer\_clk} = 1/ f_{timer\_clk}$ = 1/(15625 Hz) = 64 x $10^{-6}$ s

Required Delay = 4 s

$$Timer\ count = \frac{Required\ delay}{Timer\ Clock\ Period} - 1 = \frac{4s}{64\ x\ 10{-}6\ s} - 1 = 62499$$

Timer0 and Timer2 can count up to 255, whereas Timer1 can count up to 65,535; therefore, Timer1 is suitable for this application.

# Solution of Example 2 (Contd..)

```
void setup() {

   pinMode(REDLED_PIN, OUTPUT);

   TCCR1A = 0x00;  // Normal mode of Timer1 is used (0b00000000)
   TCCR1B = 0x05;  // Prescaler value of 1024 is used (0b00000101)
   TCNT1 = 0x0000; // Initial value of  the timer count register
                   // of Timer1 (0b0000000000000000)
}
```