University of Rwanda

Electrical Power Engineering

Module: TECHSKILLS

Y3 EPE

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Design and Implementation of an Electronic Dice using ATtiny2313

Introduction

This project involves to design, simulate, and test an electronic dice system that mimics the behavior of a physical six-sided dice. The project leverages the **ATtiny2313 microcontroller** to **control seven LEDs** arranged in a dice-like configuration. , along with **two switches** (RESET and ROLL) for control. When the **ROLL_SWITCH** is pressed, the LEDs momentarily turn off before displaying a random number between **1 and 6**, simulating a real dice roll.
The **RESET_SWITCH** clears the display, turning all LEDs off.

Objectives

The key objectives of this lab assignment are:

- To understand the interfacing of LEDs and push-button switches with a microcontroller.
- To develop skills in embedded systems programming using C and AVR Libc.
- To implement a pseudo-random number generator on a microcontroller.
- To design and simulate a fully functional electronic dice using Proteus.

To follow industry-standard embedded C coding practices as outlined in the Barr Group standards.

The implementation follows **industry-standard embedded coding practices** and includes:

- **Proteus simulation** for virtual prototyping

- **Resistor calculations** for LED current limiting
- **AVR Libc's random function** for number generation
- **Proper switch debouncing and feedback** (1-second blanking)

This guide provides a **step-by-step breakdown** of the hardware design, software implementation, testing, and submission process to ensure a successful project completion.

Step 1: Understand the Requirements

- The device must simulate a dice using an ATtiny2313 microcontroller
- It requires:
  - Seven LEDs arranged like dice dots
  - Two switches (RESET and ROLL)
  - Proper resistor calculations
- Features:
  - RESET_SWITCH turns all LEDs off
  - ROLL_SWITCH shows blank display momentarily before showing random number (1-6)
- Key achievements include:

✓ **Functional LED patterns** for numbers 1-6

✓ **Proper switch handling** (reset and roll with blanking)

✓ **AVR-based random number generation**

✓ **Proteus-verified design** before physical implementation

Step 2: Hardware Design

1. **LED Arrangement**:
   - Arrange 7 LEDs in standard dice pattern (Figure 1,2,3 in document)
   - Center LED is for odd numbers (1,3,5)
2. **Circuit Design**:
   - Use ATtiny2313 as controller (Figure 4)
   - Connect:
     - LEDs to PORTC (7 pins)
     - RESET_SWITCH to reset pin
     - ROLL_SWITCH to PB0
3. **Resistor Calculation**:
   - Calculate current-limiting resistors for LEDs
   - Example calculation (assuming 20V supply, 20mA each of 7 LED current):

- V_s=20V (supply voltage)
- V_{LED}=2 V(forward voltage of each LED)

$V_R = 20V - 2V = 18V$

$R_{LED} = I_{LED} / V_R$

$= 0.02A / 18V = \mathbf{900\Omega}$

- Use 900Ω resistors

Step 3: Proteus Simulation

1. Create new project in Proteus means Place the ATtiny2313 microcontroller.
2. Add components of seven LEDs and connect them to output pins.
   - ATtiny2313
   - 7 LEDs
   - 2 switches (push buttons)
   - Resistors (900Ω)
3. Wire according to schematic and insert pull up resistors for switches
4. Set up power supply (20V) and grounding it
5. Add current-limiting resistors in series with LEDs.
6. Upload compiled hex file from AVR-GCC to the ATtiny2313 in Proteus.
7. Simulate and verify behavior by pressing ROLL and RESET switches.

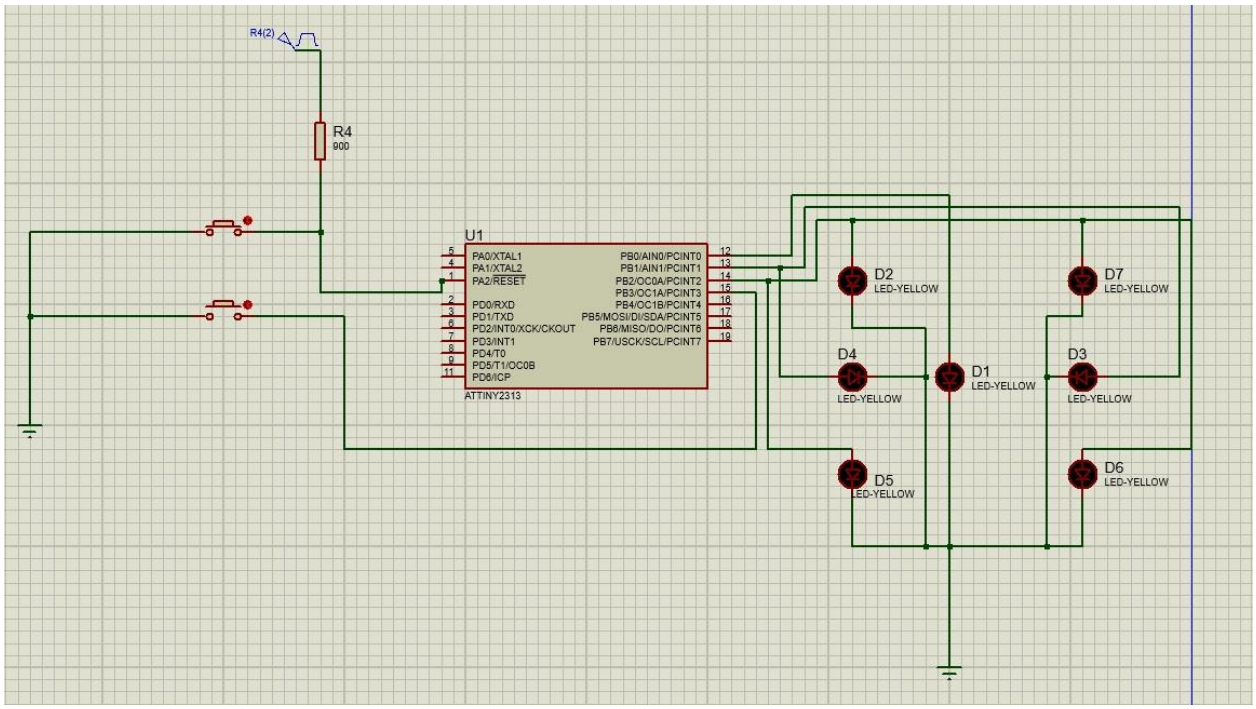

FIGURE 1: Show Proteus simulator circuit of Electronic Dice using ATtiny2313

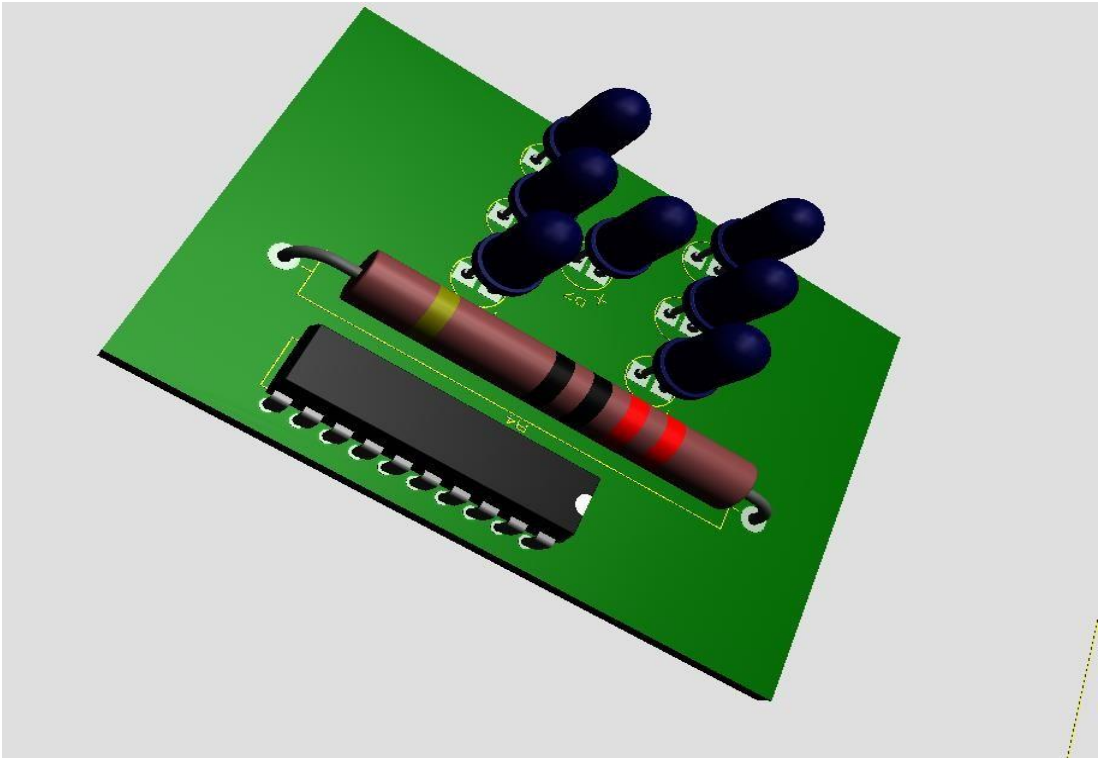

FIGURE 2: That shows PCB of Electronic Dice using ATtiny2313

Step 4: Software Implementation

```
  #define F_CPU 16000000UL
#include <avr/io.h>
#include <util/delay.h>
#include <stdlib.h>

// Define LED and switch pins
#define RESET_SWITCH (!(PINA & (1 << PA2)))
#define ROLL_SWITCH (!(PINB & (1 << PB3)))

// LED patterns for numbers 1 to 6
const uint8_t dice_patterns[] = {0b00000001, 0b00000010, 0b00001011, 0b00000100,
0b00000101, 0b00000110};

void init_ports() {
                        DDRB |= (1 << PB0) | (1 << PB1) | (1 << PB2);  // Set PORTB as output (LEDs)
                DDRA &= ~(1 << PA2); // Set PA2 as input (Reset switch)
                DDRB &= ~(1 << PB3); // Set PB3 as input (Roll switch)
        PORTB = 0x00; // Turn off all LEDs initially }
```

```
void roll_dice() {   PORTB =
0x00;      _delay_ms(10);
                PORTB = dice_patterns[rand() % 6];
}
int main(void) {
            init_ports();          srand(TCNT0);

            while (1) {                        if (RESET_SWITCH)
PORTB = 0x00;
                        if (ROLL_SWITCH) roll_dice();
            }
              return 0;
}
```

- **#define F_CPU 16000000UL:** Defines the clock speed of the microcontroller as 16 MHz, which is important for accurate timing functions.
- **#include <avr/io.h>:** Includes the AVR library for input/output functions, allowing access to microcontroller registers.
- **#include <util/delay.h>:** Includes the delay library to use functions like _delay_ms() for time delays.
- **#include <stdlib.h>:** Includes the standard library for functions like rand() for generating random numbers.
- **#define RESET_SWITCH (!(PINA & (1 << PA2))):** Defines a macro to check if the reset switch (connected to PA2) is pressed by checking if the bit is cleared.
- **#define ROLL_SWITCH (!(PINB & (1 << PB3))):** Defines a macro to check if the roll switch (connected to PB3) is pressed by checking if the bit is cleared.
- **const uint8_t dice_patterns[] = {0b00000001, 0b00000010, 0b00001011, 0b00000100, 0b00000101, 0b00000110};:** Defines an array of 6 patterns to represent dice faces using 3 LEDs for the numbers 1 to 6.

- **void init_ports() { ... }:** Initializes the microcontroller ports; sets the LED pins (PB0, PB1, PB2) as outputs, and the switch pins (PA2, PB3) as inputs.

- **DDRB |= (1 << PB0) | (1 << PB1) | (1 << PB2);:** Configures PB0, PB1, and PB2 as output pins for controlling LEDs.

- **DDRA &= ~(1 << PA2);:** Configures PA2 as an input pin for the reset switch.

- **DDRB &= ~(1 << PB3);:** Configures PB3 as an input pin for the roll switch.
- **PORTB = 0x00;:** Initializes PORTB by turning off all LEDs (setting all LED pins to low).
- **void roll_dice() { ... }:** Defines a function to simulate a dice roll by randomly selecting a dice pattern and displaying it on the LEDs.
- **PORTB = 0x00;:** Turns off all LEDs before showing a new dice pattern.
- **_delay_ms(10);:** Pauses the program for 10 milliseconds to stabilize the LED state.
- **PORTB = dice_patterns[rand() % 6];:** Randomly selects one of the 6 dice patterns from the array and displays it on the LEDs.
- **int main(void) { ... }:** Main function that continuously checks if switches are pressed and either resets or rolls the dice accordingly.
- **srand(TCNT0);:** Initializes the random number generator using the Timer/Counter 0 value to ensure random behavior on each reset.
- **if (RESET_SWITCH) PORTB = 0x00;:** If the reset switch is pressed, turn off all LEDs.

- **if (ROLL_SWITCH) roll_dice();:** If the roll switch is pressed, call the roll_dice() function to display a random dice pattern.

Step 5: Testing

1. Test in Proteus:
2. Verify random output patterns for each press of ROLL.
3. Ensure LEDs match the expected dice face.
4. Confirm RESET turns off all LEDs.

    o Press ROLL_SWITCH - should blank display then show random pattern o Press RESET_SWITCH - should clear all LEDs
5. Verify all numbers (1-6) appear randomly
6. Check timing (1 second blanking)

Conclusion

This project successfully demonstrates the use of an **ATtiny2313 microcontroller** to simulate an electronic dice with **random number generation, LED feedback, and switch control**. By following the steps outlined—**schematic design, resistor calculations, Proteus simulation, and AVR programming**—the final implementation meets all specified requirements.

This project enhances skills in **embedded systems design, microcontroller programming, and circuit simulation**, providing a solid foundation for future electronics and embedded systems work.