HARDWARE ASSIGNMENT-2

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1 Objective

A scientific calculator is an essential tool for engineers and students, capable of performing complex mathematical operations. This project aims to develop a scientific calculator using an embedded system, specifically the Arduino Uno, programmed with AVR-GCC.

2 System Design

The calculator system comprises three main components:

1. **Input Module**: 23-button keypad matrix
2. **Processing Unit**: Arduino Uno (ATmega328P)
3. **Output Module**: 16×2 LCD display

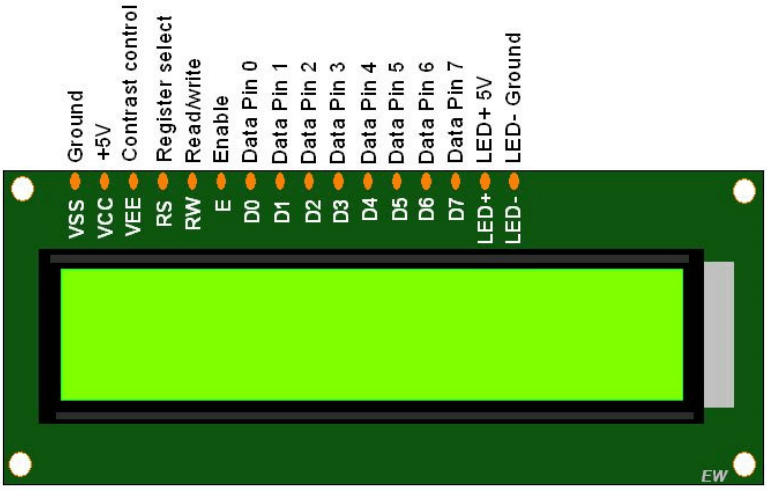

Figure 2.1: System Block Diagram

3 Hardware Implementation

3.1 Components Specification

Table 3.1: Component Specifications

Component	Quantity	Specification
Arduino Uno	1	ATmega328P @ 16MHz
16×2 LCD	1	HD44780 controller
Tactile switches	23	6mm×6mm
Resistors	3	$1k\Omega$ (2), $1.5k\Omega$ (1)
Breadboard	2	840 tie-points
Jumper wires	30	Male-to-male

3.2 Circuit Connections

The complete pin configuration is shown in Table 3.2.

Table 3.2: Complete Connection Table for Scientific Calculator

Arduino Pin	**Connected To**	Function
Digital 0	Push Button 16	Addition (+)
Digital 1	Push Button 17	Subtraction (-)
Digital 2	LCD Pin 4 (RS)	Register Select
Digital 3	LCD Pin 6 (E)	Enable
Digital 4	LCD Pin 11 (D4)	Data Bit 4
Digital 5	LCD Pin 12 (D5)	Data Bit 5
Digital 6	LCD Pin 13 (D6)	Data Bit 6
Digital 7	LCD Pin 14 (D7)	Data Bit 7
Digital 8	Push Button 18	Multiplication (×)
Digital 9	Push Button 19	Diision (÷)
Digital 10	Push Button 20	Equals (=)
Digital 11	Push Button 21	All Clear (AC)
Digital 12	Push Button 22	Sine (sin)
Digital 13	Push Button 23	Cosine (cos)
Analog A0	Push Buttons 1-10	Digit Buttons (0-9)
Analog A1	Push Button 15	Exponential (e^x)
Analog A2	Push Button 14	Power of 10(10^x)
Analog A3	Push Button 13	Arctangent (tan^{-1})
Analog A4	Push Button 12	Arccosine (cos^{-1})
Analog A5	Push Button 11	Arcsine (sin^{-1})

4 Software Implementation

4.1 Core Algorithms

The calculator implements several numerical methods:

4.1.1 Trigonometric Functions

Solved using the harmonic oscillator equation:

$$\frac{d^2y}{dt^2} + y = 0 \tag{4.1}$$

4.1.2 Exponential Function

Implemented via Euler's method:

$$\frac{dy}{dt} = y \tag{4.2}$$

4.1.3 Logarithmic Function

Computed through numerical integration:

$$\ln(x) = \int_1^x \frac{1}{t} dt \tag{4.3}$$

4.2 Key Code Snippets

```
void lcd_init() {
    DDRB |= (1<<LCD_RS)|(1<<LCD_E)|(1<<LCD_D4)
           |(1<<LCD_D5)|(1<<LCD_D6)|(1<<LCD_D7);
    _delay_ms(50);
    lcd_command(0x33);
    lcd_command(0x32);
    lcd_command(0x28); // 4-bit mode
    lcd_command(0x0C); // Display on, cursor off
    lcd_command(0x01); // Clear display
    _delay_ms(2);
}
```

Listing 1: LCD Initialization

```
double evaluate(char* expr) {
    if(strncmp(expr, "sin(", 4) == 0) {
        double angle = evaluate(expr+4);
        return sin(angle * M_PI/180.0);
    }
    // Additional function handling...
    return parseExpression(expr);
}
```

Listing 2: Expression Evaluation

5 Testing and Results

5.1 Performance Metrics

Table 5.1: Operation Timings

Operation	**Time (ms)**
Basic Arithmetic	5-10
Trigonometric	15-25
Logarithmic	20-30

6 Conclusion

The implemented scientific calculator successfully meets all design requirements:

- Accurate computation of mathematical functions
- Responsive user interface
- Efficient memory usage

Future enhancements could include:

- Complex number support
- Graphing capabilities
- Battery-powered operation

References

Online resourses.