Scientific Calculator using Arduino

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Contents

1 Introduction

- Scientific calculator is used for mathematically functions like trignometric,logarithms,exponential and arithmetic.
- In this project we mainly try to implement the logics and computational ability of an scientific calculator using arduino board,a 16x2 LCD display and a button matrix for numericals and functions
- Following are the logics to implement the calculation of the mathematical functions efficently and accurately
  - CORDIC algorithm for trignometric functions
  - RK4 for logorithm and exponential
  - Common math operators for arithmetic operator

2 Components

The following bullet points provides the components and their function briefly

- **Arduino Uno -** Used as the brain of the calculator which uploads and recieves the input and and send cammands to display the expression and output in LCD display
- **16x2 LCD display -** displays the input and output
- **Buttons Matrix -** Buttons are used for giving input in which we assign a character to each button.
  There are two modes for each button,
  - Mode 1 - for numbers and basic arithmetic operations
  - Mode 2 - for mathematical functions trignometric,logorithmic etc

  And a button to switch between the modes
- **Resistors and Wires -** Resistor for controlling the current and wires for connections
- **Potentiometer -** For controlling the contrast of the LCD display

Component	Arduino Pin
Button Matrix	
Row 1	2
Row 2	3
Row 3	4
Row 4	5
Column 1	6
Column 2	7
Column 3	8
Column 4	9
Column 5	10
Shift Button	
Shift Button	13
GND	GND
LCD Display (16x2, Non-I2C)	
LCD RS	A0
LCD EN	A1
LCD D4	A2
LCD D5	A3
LCD D6	A4
LCD D7	A5

Table 1: Circuit Connections of the Scientific Calculator

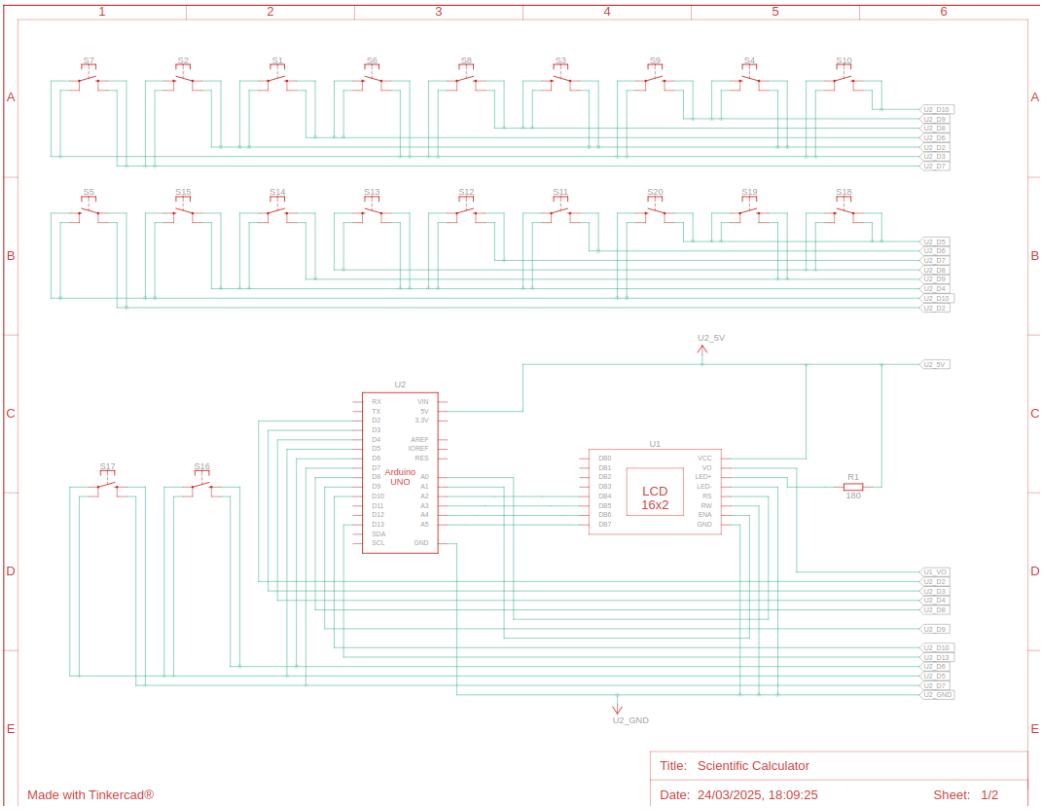

Figure 1: Circuit Diagram of the Scientific Calculator (Sheet 1)

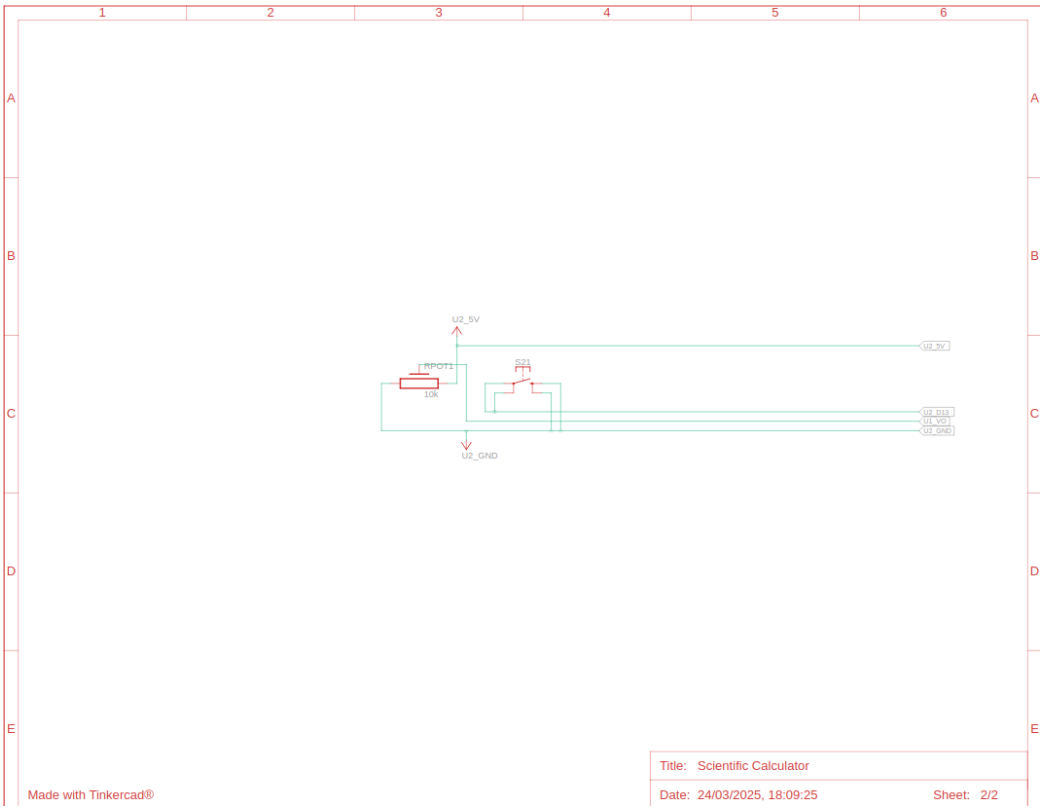

Figure 2: Circuit Diagram of the Scientific Calculator (Sheet 2)

3 Functions Available

The calculator supports following mathematical operations.

3.1 Mode-1 Button Layout

1	2	3	/	C
4	5	6	*	D
7	8	9	-	(
.	0	=	+	)

Table 2: Mode-1 button layout

3.2 Mode-2 Button Layout

sin	cos	tan	x^y	C
!	π	e	$\|x\|$	D
log	ln	sqrt	cbrt	r
sin^{-1}	cos^{-1}	tan^{-1}	x^2	x^3

Table 3: Mode button layout

4 Numerical Methods

For accuracy and efficency the calculator uses the following numerical methods

- **CORDIC Algorithm for Trignometric funtions**

$$x_{i+1} = x_i - d_i \cdot y_i \cdot 2^{-i}$$
$$y_{i+1} = y_i + d_i \cdot x_i \cdot 2^{-i}$$
$$z_{i+1} = z_i - d_i \cdot \text{atan}(2^{-i})$$

  where:

  - x, y represent the coordinates of the rotated vector.
  - z is the angle being processed.
  - d_i is the sign of z.

  It used for sin(x),cos(x) and tan(x).

- **RK4 Algorithm for logarithmic and power functions**

$$k_1 = hf(x_n, y_n)$$
$$k_2 = hf(x_n + \frac{h}{2}, y_n + \frac{k_1}{2})$$
$$k_3 = hf(x_n + \frac{h}{2}, y_n + \frac{k_2}{2})$$
$$k_4 = hf(x_n + h, y_n + k_3)$$
$$y_{n+1} = y_n + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$

  Applications in the calculator

  - **Logarithms**
  - **Exponential**
  - **Square and Cube Roots**
  - **Inverse Trignometric Functions**

5 Expression Evaluation Logic

To handle complex expressions, the calculator uses:

- **Stack-based computation**: Uses two stacks for values and operators.
- **Operator precedence rules**: Implements precedence to ensure correct order of operations.
- **String parsing**: Extracts numbers, operators, and function names.
- **Error handling**: Handles division by zero and invalid inputs.

6 Implementation Challenges and Solutions

- **Handling Button Multiplexing**: Since the number of input pins is limited, a multiplexing technique was used to read button presses efficiently.
- **Non-I2C LCD Handling**: The LCD was operated in 4-bit mode to optimize pin usage.
- **Efficient Mathematical Computation**: Using CORDIC and RK4 improved accuracy while reducing computation time.

7 Conclusion

- This scientific calculator successfully implements a variety of mathematical functions using efficient numerical methods. The combination of CORDIC and RK4 ensures accurate and fast computations.
- The button matrix provides an intuitive interface, making it a practical and functional scientific calculator.

For codes refer
`https://github.com/naraprajwal/EE1003/tree/ee654ce2686dc1c07586fa8eb6452a7e21e71`
`Calculator/codes`

Thank you