

Scientific Calculator using Arduino

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Contents

1 Introduction

- Scientific calculator is used for mathematical functions like trigonometric, logarithms, exponential and arithmetic.
- In this project we mainly try to implement the logics and computational ability of a scientific calculator using an 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 efficiently and accurately
 - CORDIC algorithm for trigonometric functions
 - RK4 for logarithm and exponential
 - Common math operators for arithmetic operator

2 Components

The following bullet points provide the components and their function briefly

- **Arduino Uno** - Used as the brain of the calculator which uploads and receives the input and sends commands 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 trigonometric, logarithmic 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

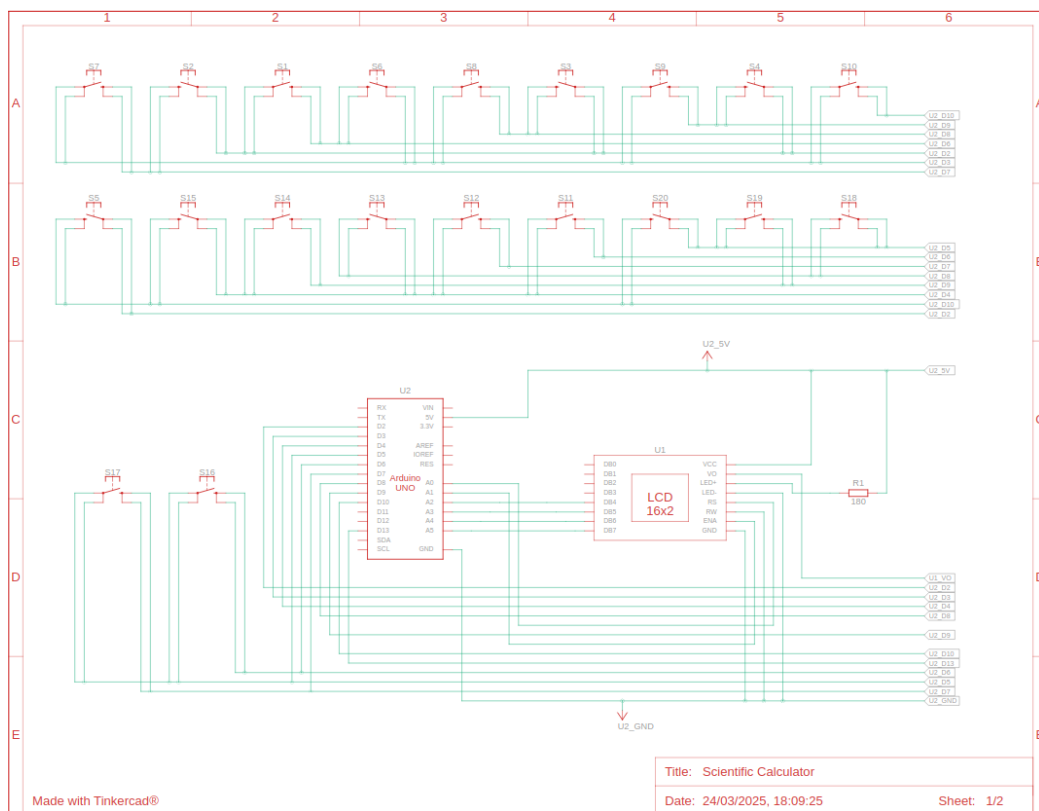


Figure 1: Circuit Diagram of the Scientific Calculator (Sheet 1)

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 efficiency the calculator uses the following numerical methods

- **CORDIC Algorithm for Trigonometric functions**

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

where:

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

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

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

$$\begin{aligned}k_1 &= hf(x_n, y_n) \\k_2 &= hf\left(x_n + \frac{h}{2}, y_n + \frac{k_1}{2}\right) \\k_3 &= hf\left(x_n + \frac{h}{2}, y_n + \frac{k_2}{2}\right) \\k_4 &= hf(x_n + h, y_n + k_3) \\y_{n+1} &= y_n + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4)\end{aligned}$$

Applications in the calculator

- **Logarithms**
- **Exponential**
- **Square and Cube Roots**
- **Inverse Trigonometric 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/ArnavYadnopavit/EE1003/tree/main/Calculator>

Thank you