Calculator with RaspberryPI PICO

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***Abstract*—This document presents the design and implementation of a basic calculator using a Raspberry Pi Pico microcontroller, a 4x4 Keypad Module, and an I2C 16x2 LCD Display. The calculator allows users to perform addition, subtraction, multiplication, and division operations by pressing the corresponding keys on the keypad. The arithmetic expressions are displayed in real-time on the I2C LCD, providing a user-friendly interface. The system leverages the MicroPython programming language, making it accessible for hobbyists and educators. The document outlines the hardware connections, code structure, and functionality of the calculator, offering a valuable resource for individuals interested in exploring embedded systems and microcontroller programming.**

I. Introduction

In an era marked by the proliferation of embedded systems, the fusion of hardware and software has given rise to innovative applications across diverse domains. This document unveils a hands-on exploration into the realm of embedded system design, featuring a Raspberry Pi Pico-based calculator equipped with a 4x4 Keypad Module and an I2C 16x2 LCD Display. With a focus on simplicity and functionality, this project serves as an ideal introduction for enthusiasts, educators, and hobbyists seeking to delve into the intricacies of microcontroller programming and human-machine interaction.

The integration of the Raspberry Pi Pico microcontroller, coupled with a tactile 4×4 keypad and an I2C-enabled LCD display, showcases the potential for creating interactive and user-friendly embedded systems. This paper details the step-by-step implementation of the calculator, shedding light on hardware connections, software development using MicroPython, and the overall functionality of the system.

As readers embark on this journey, they will gain insights into fundamental concepts of embedded systems, real-time interaction, and the practical aspects of marrying hardware components with software logic. By providing a comprehensive overview of the design, development, and deployment of the Raspberry Pi Pico-based calculator, this document aims to empower enthusiasts with the knowledge and skills necessary to undertake similar projects. Whether for educational purposes, prototyping, or personal exploration, the presented system encapsulates the essence of hands-on learning in the dynamic field of embedded systems. Through this exploration, readers are invited to engage with the fascinating intersection of hardware and software, unlocking the potential for creativity and innovation in the ever-evolving landscape of embedded technology.

II. Components used

A. *Raspberry Pi Pico:*

The Raspberry Pi Pico is a versatile microcontroller based on the RP2040 chip. Featuring a dual-core ARM Cortex-M0+ processor, it provides ample processing power for various applications. The Pico offers GPIO pins for interfacing with external devices, SPI, I2C, and UART communication capabilities, making it an ideal choice for embedded systems projects. Its open-source nature and compatibility with MicroPython facilitate rapid development and experimentation, making it accessible to both beginners and experienced developers.

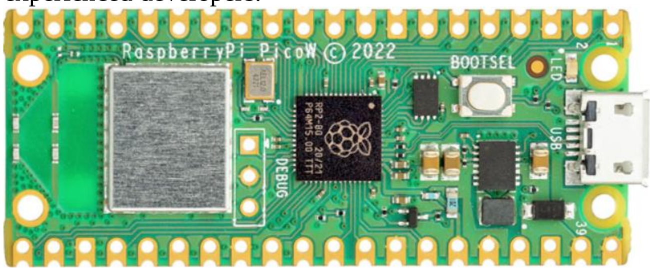

Fig. 1. Raspberry pi pico

B. *4×4 Keypad Module:*

The 4x4 keypad module offers a tactile and intuitive interface for user input. Comprising 16 keys arranged in a matrix of rows and columns, it simplifies wiring and scanning of inputs. Each key is a momentary switch, ensuring reliable and responsive feedback. The matrix configuration allows multiple keys to share the same GPIO pins, minimizing the number of required input pins on the microcontroller. Its robust design and ease of integration make it suitable for various applications demanding user interaction.

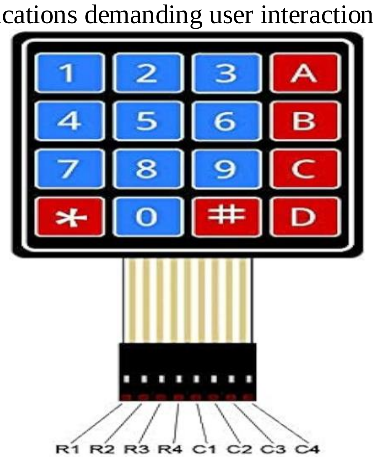

Fig. 2. 4×4 Keypad module

C. I2C 16×2 LCD Display:

The I2C 16×2 LCD display is a compact alphanumeric display that communicates over the I2C protocol, requiring only two wires for data transmission. Its 16×2 configuration means it can display 16 characters in each of its two rows. This type of display offers clear and readable output, making it suitable for conveying real-time information. The I2C interface simplifies the connection to the microcontroller and reduces the number of required pins. The contrast and backlight can often be adjusted, enhancing visibility in different lighting conditions.

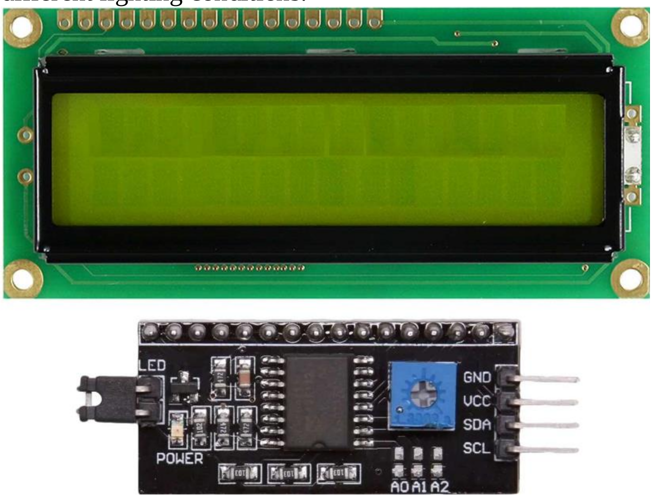

Fig. 3. I2C 16×2 LCD Display

D. Jumper Wires for Connections:

Jumper wires play a crucial role in establishing the physical connections between the components. They provide a flexible and convenient means of linking the GPIO pins of the Raspberry Pi Pico to the corresponding pins on the keypad and LCD display. Their male-to-female or male-to-male configurations facilitate easy wiring and organization within the project. The correct placement and secure connections of jumper wires are essential for ensuring proper communication and power distribution among the components.

Fig. 4. Jumper Wires

E. Breadboard:

The breadboard serves as a platform for prototyping and connecting electronic components. It features a grid of holes arranged in rows and columns, allowing for the insertion of jumper wires and the placement of components. The breadboard eliminates the need for soldering during the development phase, enabling quick and reversible modifications to the circuit layout. It is an invaluable tool for testing and iterating on electronic designs.

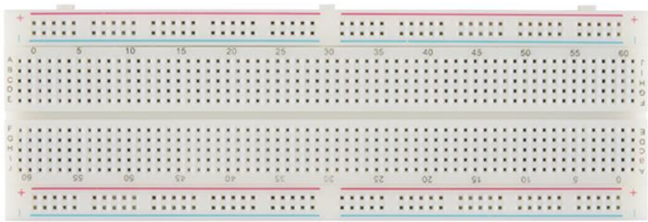

Fig. 5. Breadboard

F. USB to Micro-B Cable:

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Fig. 6. USB to Micro-B Cable

III. Connection Setup

A. Connect Raspberry Pi Pico to Breadboard:

Place the Raspberry Pi Pico on the breadboard, ensuring the GPIO pins align with the breadboard's rows. Use jumper wires to connect the necessary GPIO pins on the Raspberry Pi Pico to the corresponding rows on the breadboard. Connect the 3.3V and GND pins to provide power to the breadboard.

Fig. 7. Connected Raspberry Pi Pico with breadboard

B. Connect I2C 16×2 LCD Display to Raspbery Pi Pico:

Connect the I2C 16x2 LCD Display to the Raspberry Pi Pico using jumper wires. Link the LCD's SDA pin to GPIO 0 and the SCL pin to GPIO 1 for I2C communication. Additionally, connect the VCC pin to the positive power rail and the GND pin to the negative power rail on the breadboard to power the LCD display. These connections establish the necessary communication and power lines for the LCD, enabling it to display real-time data from the Raspberry Pi Pico.

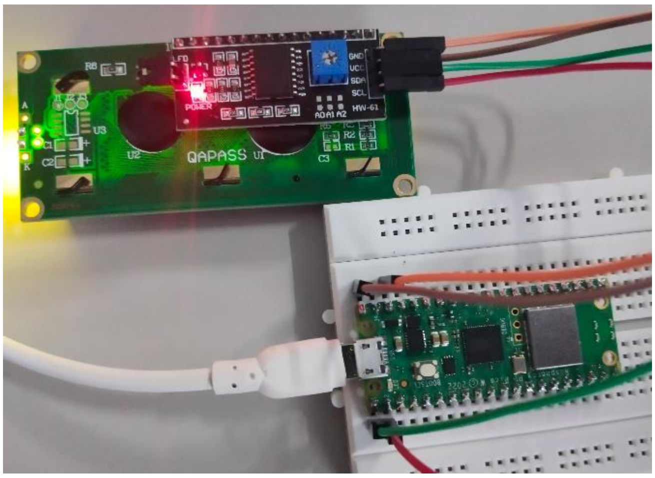

Fig. 8. Connected I2C 16×2 LCD Display to Raspberry Pi Pico

C. Connect 4×4 Keypad Module to Raspbery Pi Pico:

The 4x4 keypad module offers a tactile interface with 16 keys arranged in rows (R1 to R4) and columns (C1 to C4). This matrix design simplifies wiring and scanning of inputs, with each key acting as a momentary switch for reliable feedback. Notably, R1 to R4 are connected to GPIO pins 2, 3, 4, and 5, while C1 to C4 are connected to GPIO pins 6, 7, 8, and 9 on the Raspberry Pi Pico. This configuration optimizes GPIO usage, minimizing the required input pins and showcasing the keypad's versatility for various user interaction applications.

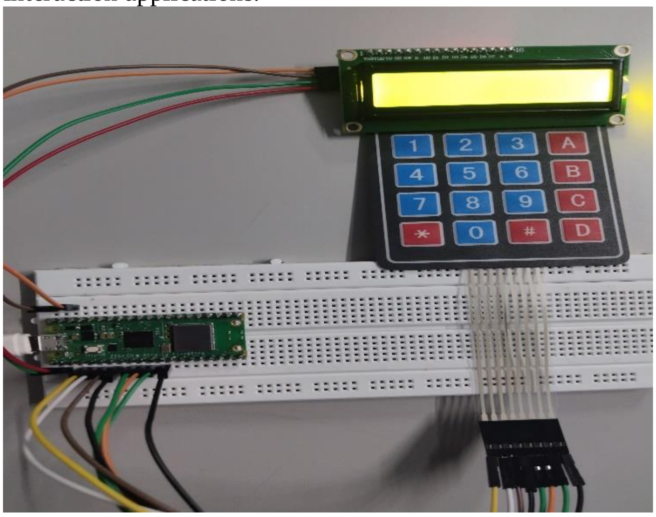

Fig. 9. Connected I2C 16×2 LCD Display to Raspberry Pi Pico

TABLE I

4*4 Matrix Membrane Keypad	Raspberry Pi Pico Pins
R1	GPIO2
R2	GPIO3
R3	GPIO4
R4	GPIO5
C1	GPIO6
C2	GPIO7
C3	GPIO8
C4	GPIO9

D. Connect the USB to Micro-B Cable to Raspberry Pi Pico

Connect the USB to Micro-B cable to the Raspberry Pi Pico to provide power. Ensure that the power supply meets the voltage and current requirements of the components. Verify that the connections are secure and free from short circuits

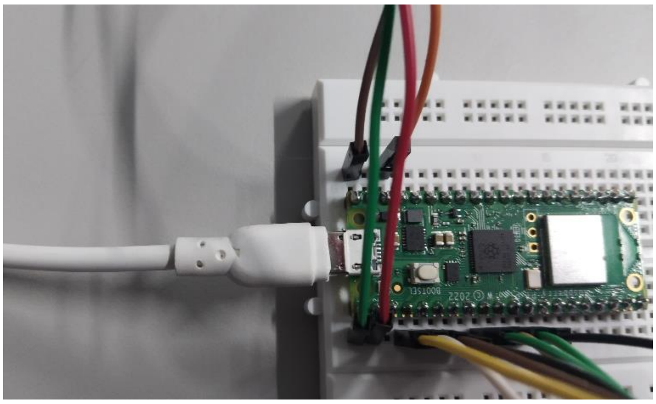

Fig. 10. Connection of Pico and USB to Micro-B Cable

IV. Methodlogy

A. User Input:

1. Users press the corresponding keys on the 4x4 keypad to input numerical values from 0 to 9.
2. To To include arithmetic operations, users press the relevant keys on the keypad (+, -, *, /).
3. Each key press contributes to building the arithmetic expression.
4. Users utilize the 'c' key on the keypad to clear the current input. This function allows users to reset the input and start a new calculation.

B. I2C 16×2 LCD Display:

The I2C 16x2 LCD Display provides real-time feedback as users input values and operations. Pressing '=' displays prompt results, and an 'IE' indicator appears for invalid expressions. The 'c' key efficiently clears input for a new calculation, ensuring a seamless and user-friendly experience.

V. CONCLUSION

In conclusion, the Raspberry Pi Pico-based calculator project represents a successful fusion of hardware and software, delivering an engaging and user-friendly embedded system. Through the seamless integration of a 4x4 keypad for input and an I2C 16x2 LCD Display for instant feedback, the project exemplifies the effective synergy between these core components. The outlined methodology provides a clear and structured guide for hardware connections, MicroPython code development, and meticulous testing procedures, making it a valuable educational resource.

In essence, the Raspberry Pi Pico-based calculator project showcases a user-centric design for effortless numerical input and arithmetic operations. The system's swift response and immediate error feedback contribute to a seamless user experience. Beyond its educational value, the project serves as a practical application of the Raspberry Pi Pico, offering a tangible and interactive calculator interface.

Overall, the project demonstrates the versatility of the Raspberry Pi Pico, inviting exploration within the embedded systems community. It stands as a testament to the potential of microcontroller-based projects, fostering practical learning and innovation in the dynamic landscape of embedded systems.

The clear and concise user interface, complemented by dynamic LCD feedback, enhances user interaction and underscores the project's commitment to effective communication. Real-time displays of expressions and prompt results provide transparency and responsiveness in calculations.

VI. REFERENCES

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