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KPAD

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Final Course Project

DRAF127 / DRAF227

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INTRODUCTION

This project is a customizable macro pad designed to allow users to assign their own shortcuts and macros to physical buttons for convenience and productivity. It was designed using Altium Designer and coded using CircuitPython and the KMK library.

As a computer science student with a growing interest in hardware and circuit design, I wanted to combine my coding background with my new skills in electronics and PCB design. The main inspiration behind this project came from frequently using software with numerous shortcuts, and the desire to simplify my workflow by reducing the need to remember them all. Additionally, this project served as an opportunity to apply the PCB design skills I had recently learned with Altium Designer to a practical, real-world application.

METHODS

DESIGN

The circuit is relatively simple but effective. The core components include:

- *12 mechanical switches*
- *Two 74HC165 shift registers*
- *Xiao RP2040 microcontroller*
- *Rotary encoder*
- *128x32 OLED display*

Each switch is connected to the shift registers with pull-up resistors to maintain a default HIGH state. The shift registers help minimize the number of GPIO pins required by serializing the switch data, allowing the use of a compact microcontroller like the Xiao RP2040.

The rotary encoder and OLED display connect directly to the microcontroller using I2C (for the display) and digital pins (for the encoder).

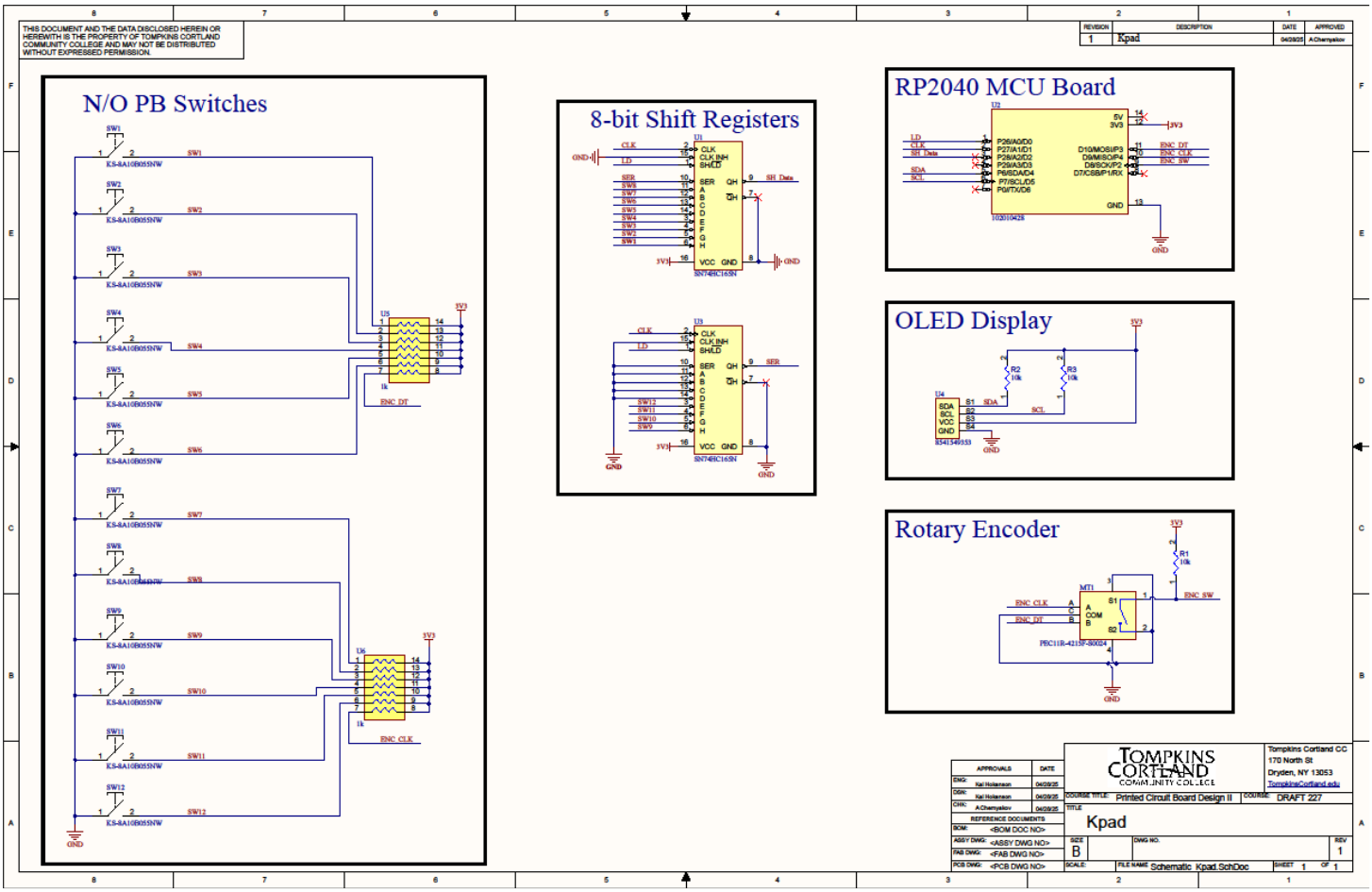


FIGURE 1: SCHEMATIC

PROTOTYPING THE CIRCUIT USING REAL COMPONENTS

The prototype was built using two breadboards:

- *One held the microcontroller, shift registers, OLED display, and rotary encoder.*
- *The other held the mechanical switches and pull-up resistors.*

The connections between the breadboards were made with wires. An issue encountered during prototyping involved the switches creating floating connections when removed from the breadboard, which did not affect the final product but was important to note during testing.

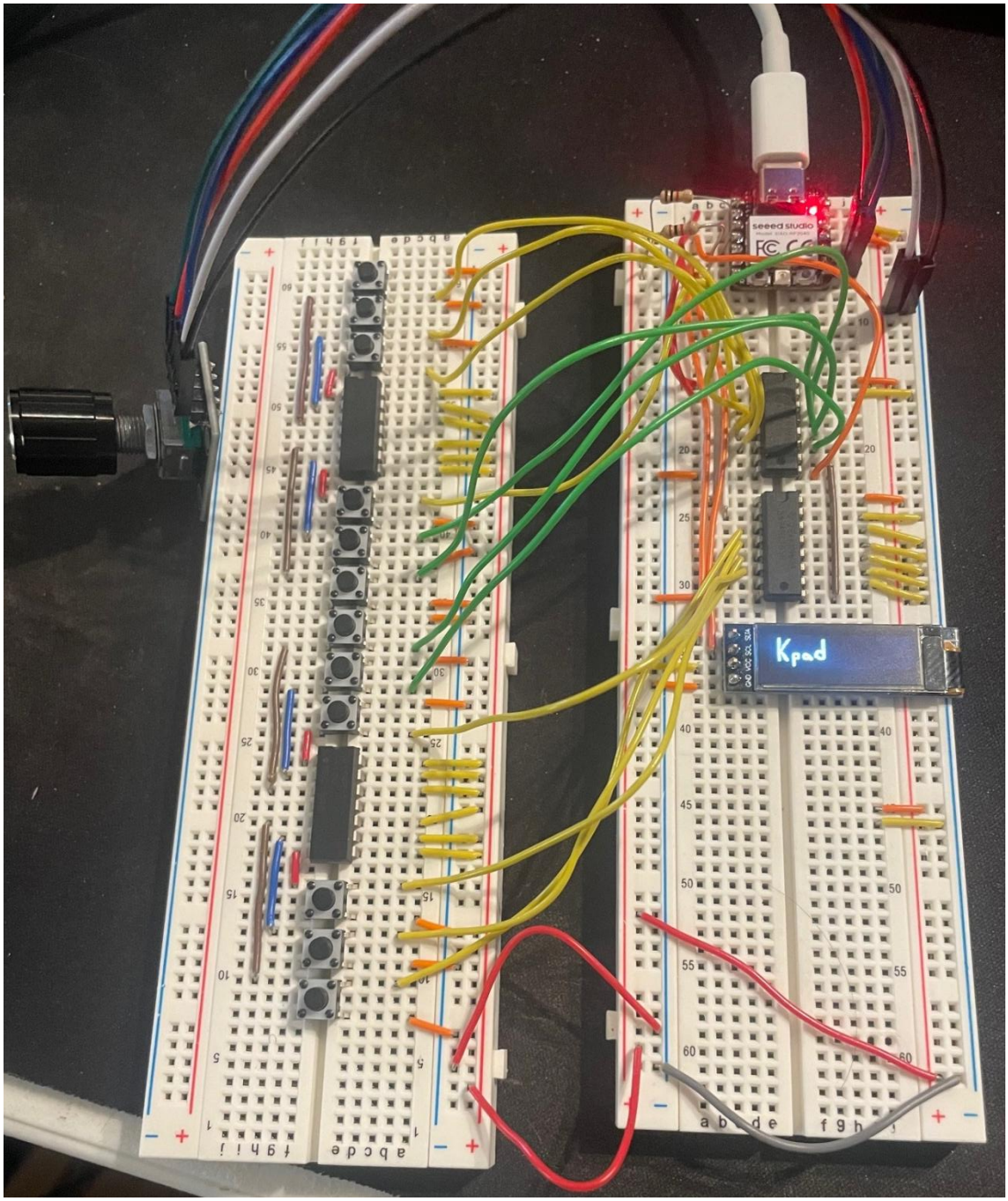


FIGURE 2: PROTOTYPE CIRCUIT

PRINTED CIRCUIT BOARD DESIGN

Design Tool Used:
Altium Designer with Altium 365

PCB LAYOUT

- **Dimensions:** *[94mm x 100mm]*
- **Number of Layers:** *2 (Top Layer and Bottom Layer)*

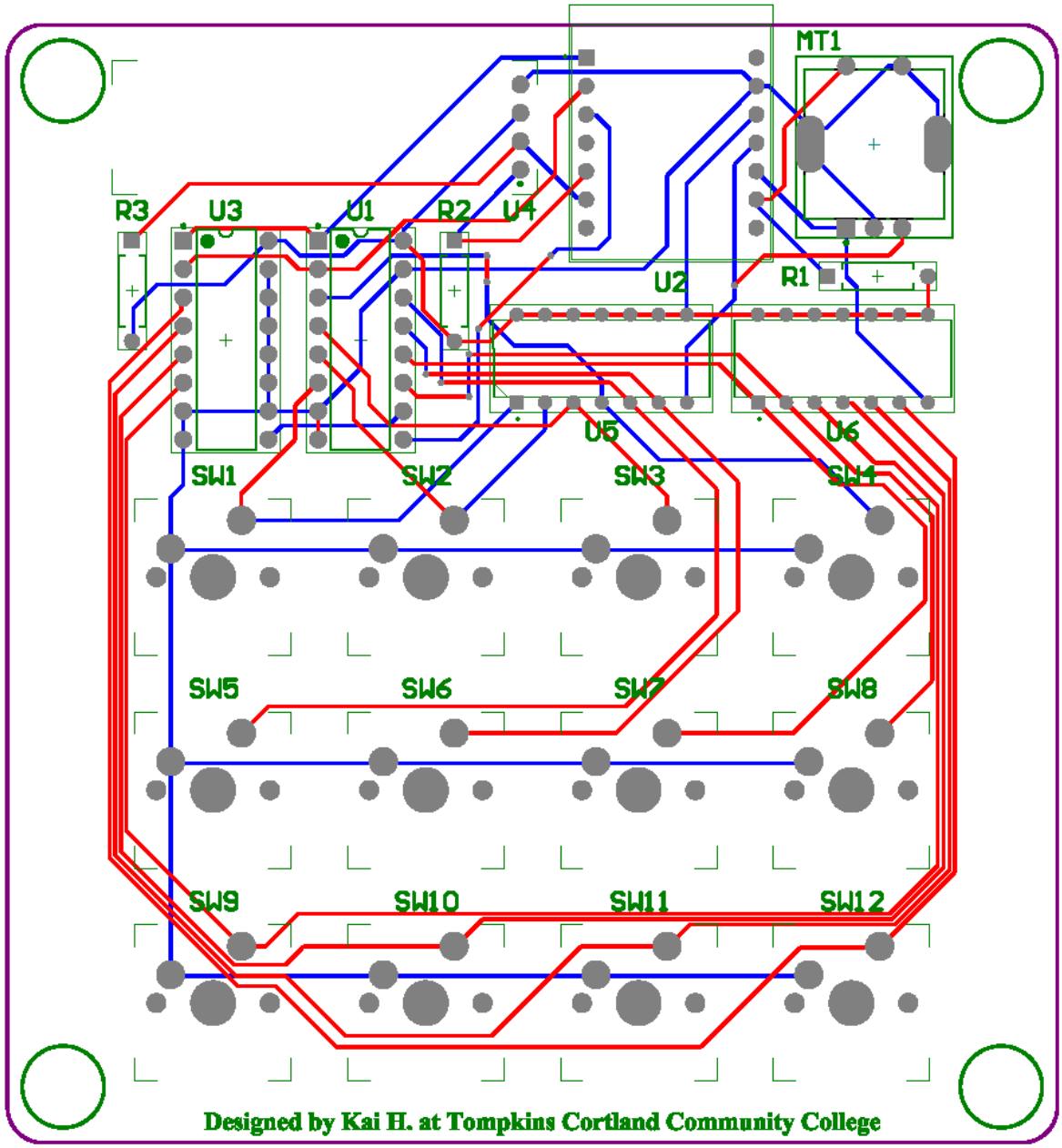


FIGURE 3: STACKUP LAYER

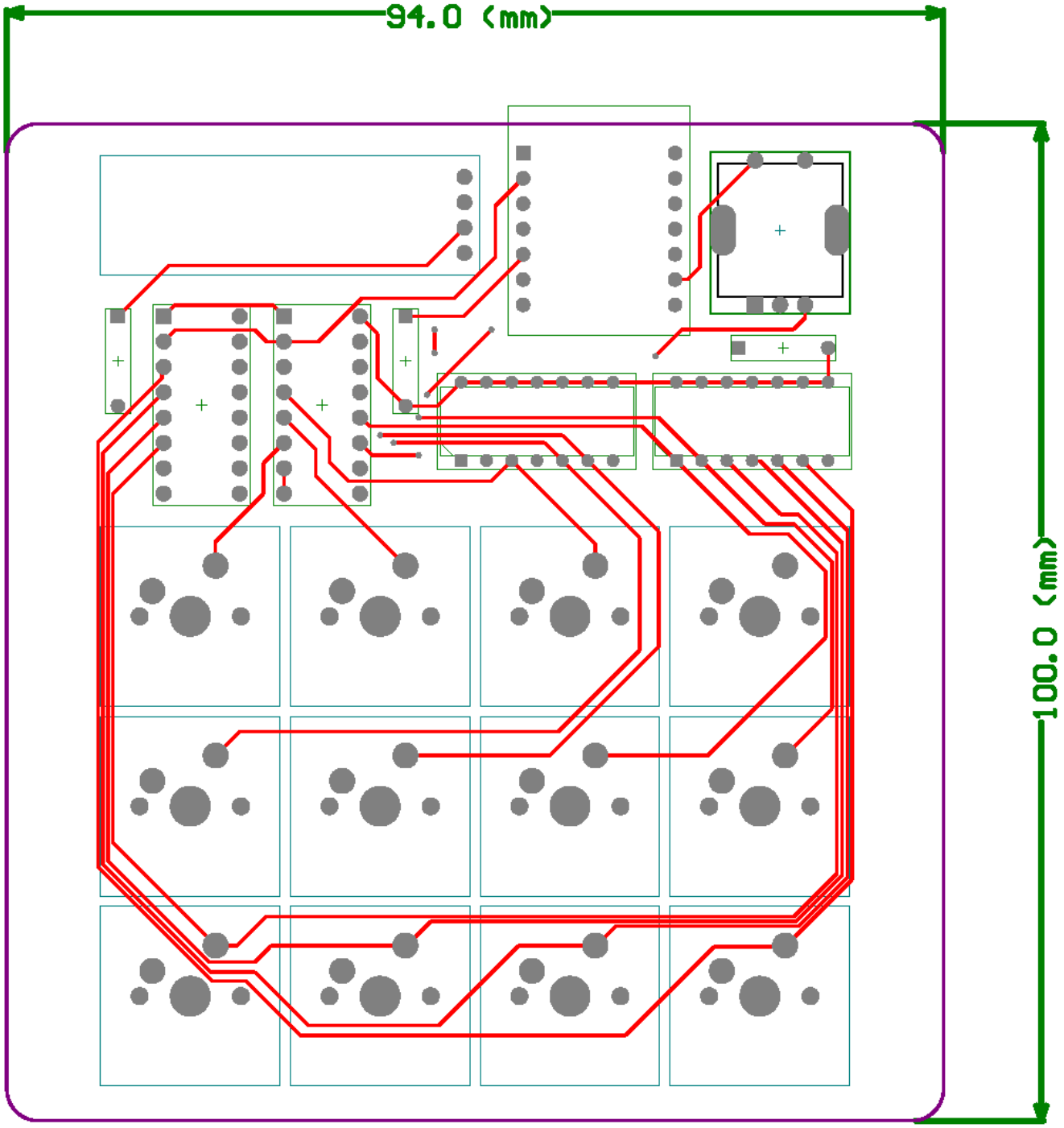


FIGURE 4: TOP LAYER

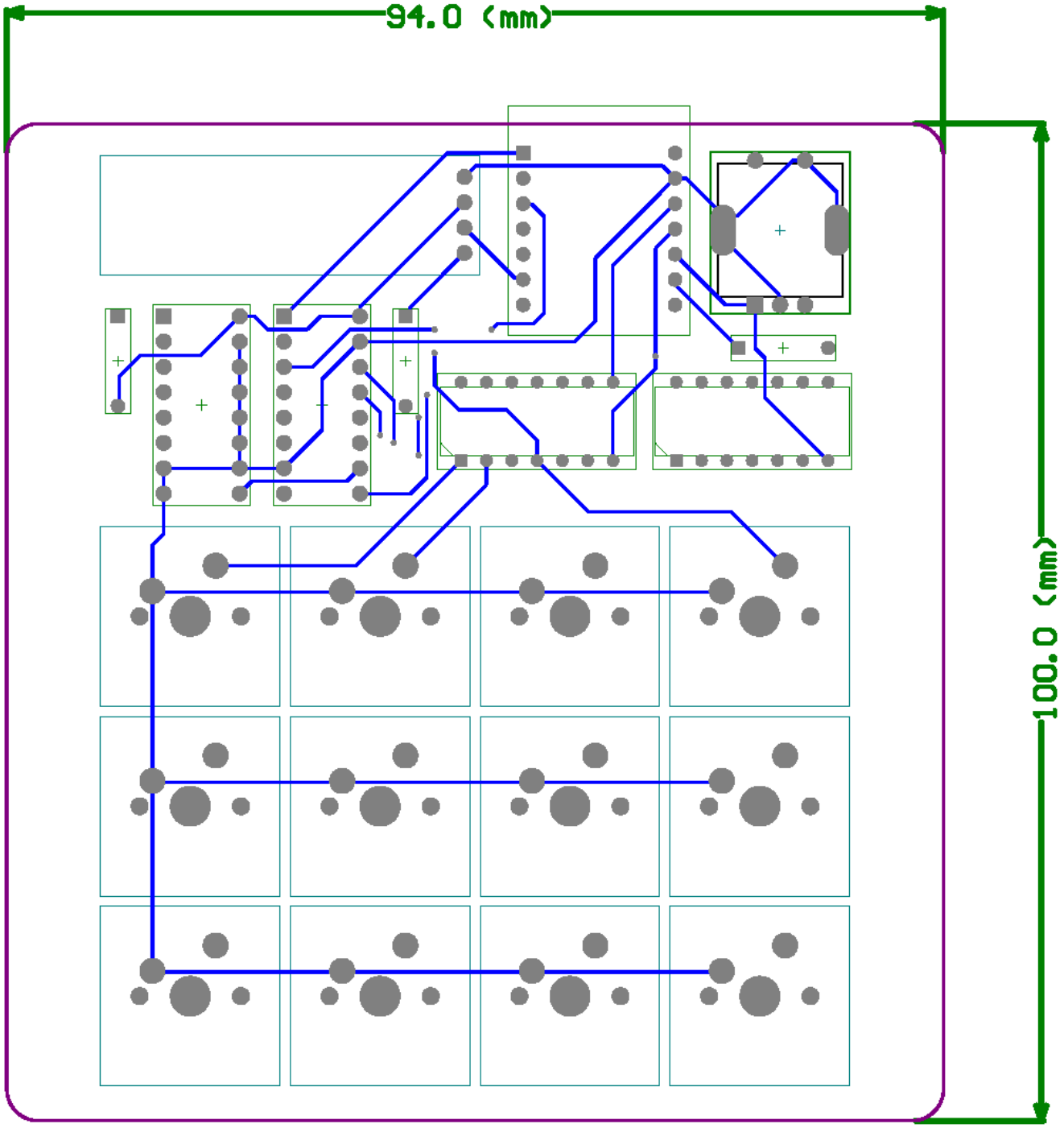


FIGURE 5: BOTTOM LAYER

3D VIEW

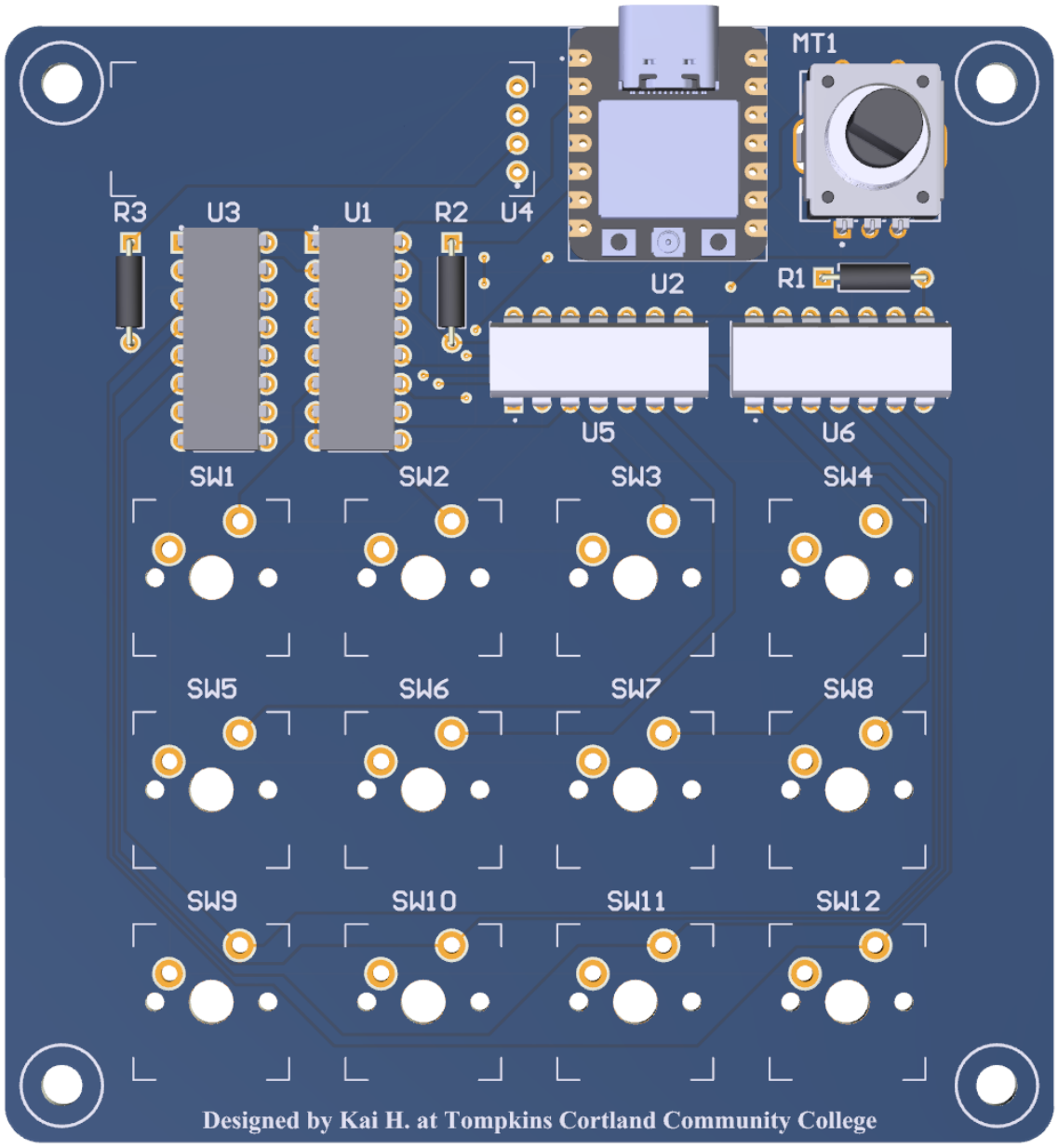


FIGURE 6: 3D TOP LAYER

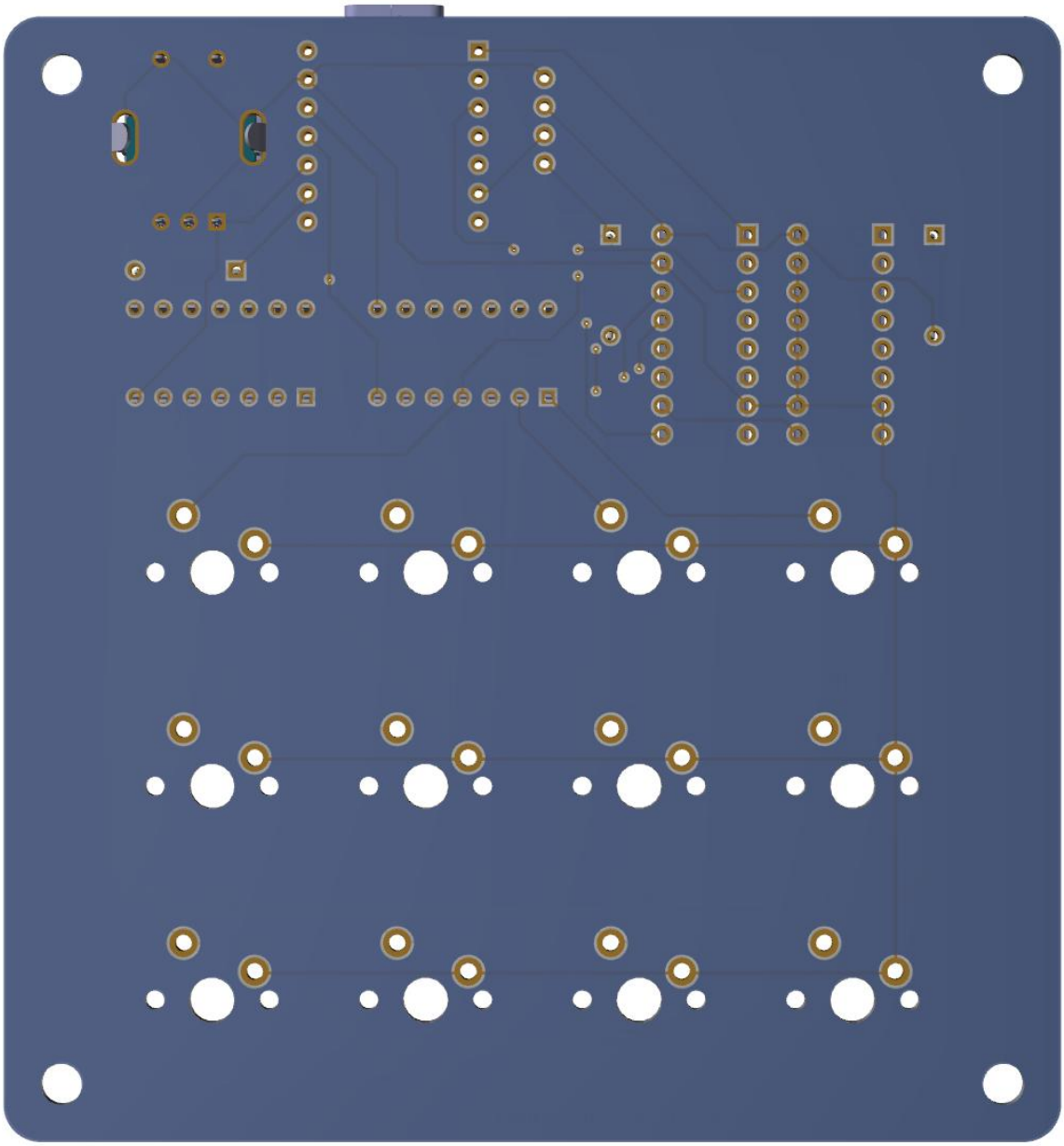


FIGURE 7: 3D BOTTOM LAYER

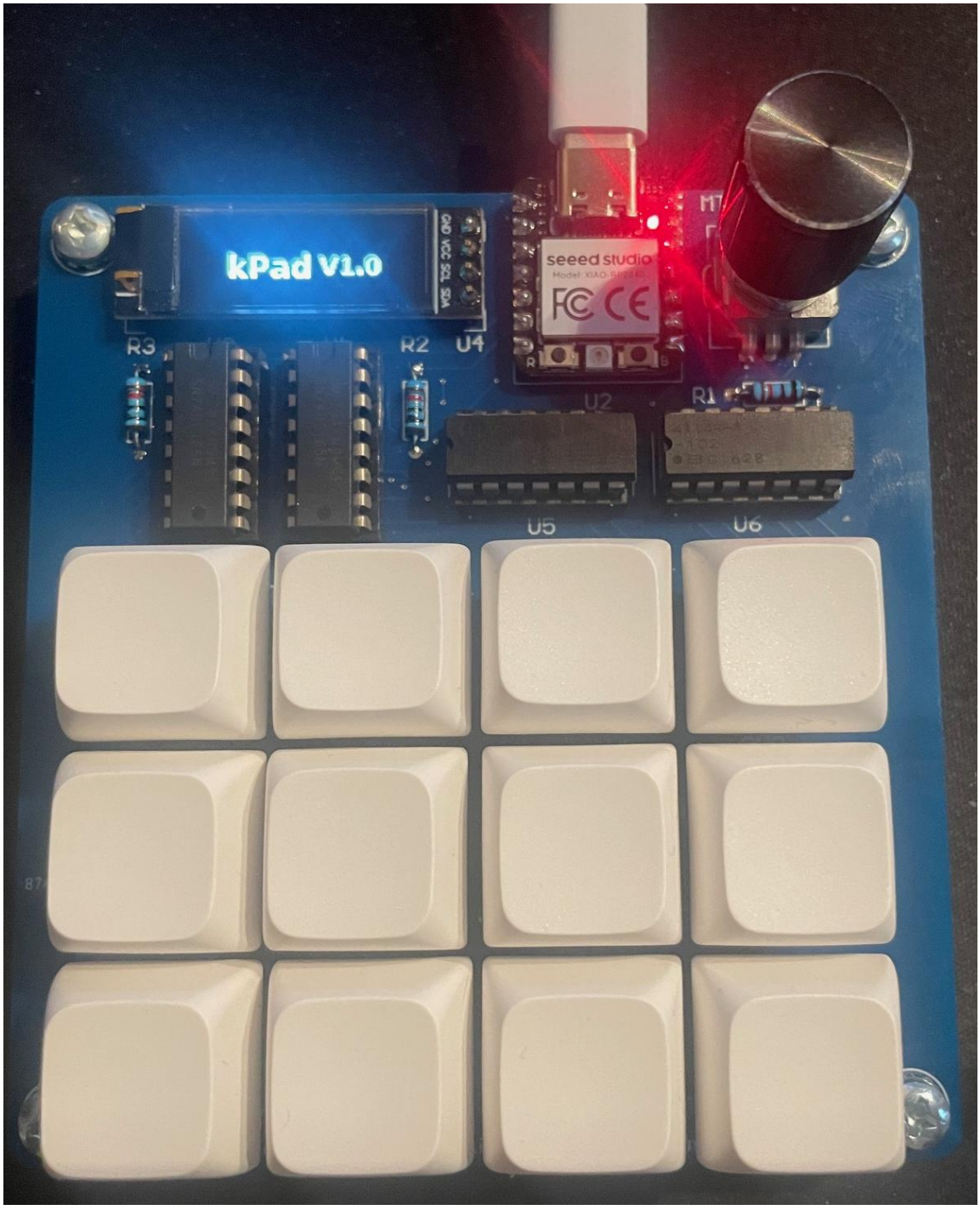
BILL OF MATERIALS (BOM)

Designator	Description	Name	Quantity	Manufacturer 1	Manufacturer Part Number 1	Supplier 1	Supplier Part Number 1
MT1	Incremental Encoder, 12 Mm, Contact Rating 10 Ma - 5 Vdc	PEC11R-4215F-S0024	1	Bourns	PEC11R-4215F-S0024	Arrow Electronics	PEC11R-4215F-S0024
R1, R2, R3	Axial Resistor, 10 KOhm, +/- 1%, 0.25 W, -55 to 155 degC, 2-Pin THD, RoHS, Bulk	MFR-25FBF52-10K	3	Yageo	MFR-25FBF52-10K	Avnet	MFR-25FBF52-10K
SW1, SW2, SW3, SW4, SW5, SW6, SW7, SW8, SW9, SW10, SW11, SW12	SPST momentary switch 15.40mmx15.40mm	KS-8A10B055NW	12	Gateron	KS-8A10B055NW-D194	Divinikey	DK002607
U1, U3	Parallel-Load Shift Register, 8-Bit, 2 to 6 V, -40 to 125 degC, 16-Pin PDIP (N), Pb-Free (RoHS), Rail/Tube	SN74HC165N	2	Texas Instruments	SN74HC165N	Digikey	296-8251-5-ND
U2	RP2040 XIAO RP2040 series ARMÂ® CortexÂ®-M0+ MCU 32-Bit Embedded Evaluation Board	102010428	1	Seeed Technology Co., Ltd	102010428	Digikey	1597-102010428-ND
U4	MakerFocus 2pcs I2C OLED Display Module 0.91 Inch	8541549353	1	Shenzhen Jin Ma Ding Electronics Co., Ltd.	QG-2832TLBFG02	MakerFocus	8541549353
U5, U6	RES ARRAY 7 RES 1K OHM 14DIP	4114R-1-102LF	2	Bourns	4114R-1-102LF	Newark	32K8310

TABLE 1: BILL OF MATERIALS

BUILD THE CIRCUIT

The final PCB was hand soldered. Each component was carefully placed and soldered according to the designed footprint and schematic.



TEST CIRCUIT

The completed circuit was powered via USB and tested by running a test version of the code to confirm switch presses, encoder operation, and display functionality. Both the hardware and software worked as expected on the first test.

CODE

The firmware was written in CircuitPython using the KMK keyboard library. KMK provides a framework for defining custom macros, handling key matrix scanning (via shift registers in this case), and interfacing with the OLED display and rotary encoder.

CONCLUSION

The approach taken in this course, moving from schematic design to prototyping and then to a fully assembled PCB, was highly effective. This project met my expectations in both functionality and as a learning experience. It gave me practical experience in designing, prototyping, and assembling a real-world electronic device. Additionally, it helped me improve my skills in Altium Designer, debugging circuits, and integrating hardware with code. After completing this, I feel much more prepared and comfortable tackling future design projects.