S2-08
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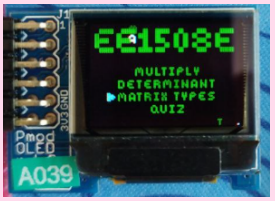
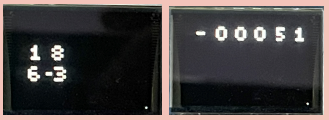
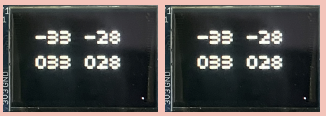
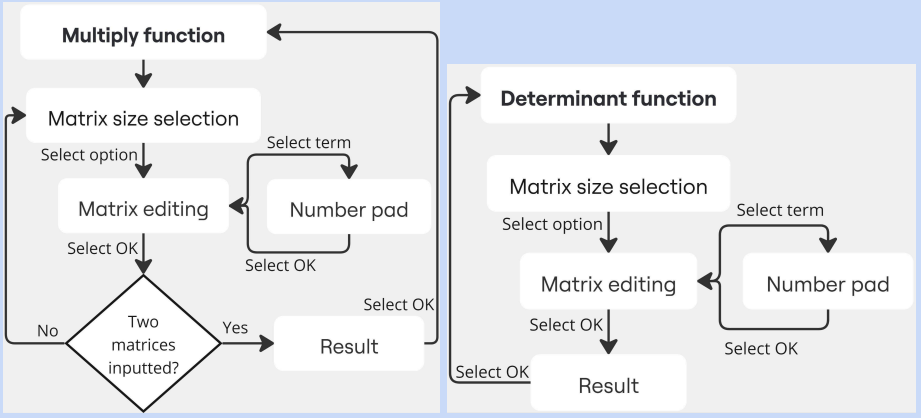
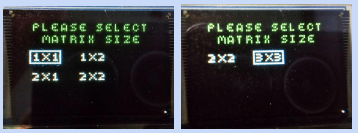
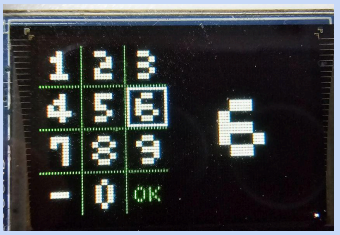
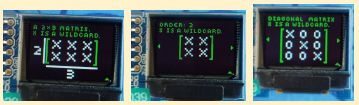
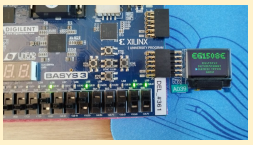
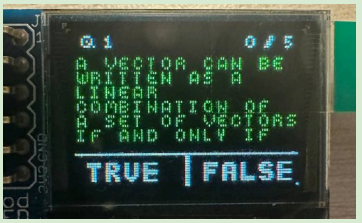
Student & Improvement Name	Improvement Description	Images/Photos
Team: "S2-08" Project Title: EE1508E: Linear Algebra for Veriloggers	A mini app to help students with Linear Algebra. The entire app is aesthetically themed after the movie "The Matrix" (cuz matrices). Contains 4 main features: **Multiply:** Helps users find the product of 2 matrices of size up to 2 x 2. **Determinant:** Helps users calculate the determinant of a 2x2 or 3x3 matrix. **Matrix Types:** A catalog of a few special matrix types for the user's reference. **Quiz:** Quizzes the user on 5 True/False questions about linear algebra. General Navigation: BTNU, BTNL, BTND and BTNR are used to move up, down, left and right respectively. BTNC is used to select. Switching on SW15 causes the program to **return to the main menu**. SW15 must be switched off to return to **normal program functionality**.	
Student A: Nathan Logic and calculations for Matrix Multiplication and Determinant	**Input** The program allows users to input signed digits ranging from -9 to 9 and save them to variables. For determinant calculations, it can process 2x2 and 3x3 matrices, yielding a determinant result with up to 4 digits. For matrix multiplication, the program can handle multiplication of two 2x2 matrices. It also supports other matrix sizes, such as 1x1, 1x2 & 2x1, and multiplication of valid combinations of the above. **Parsing Results** The program displays results by parsing each digit individually, accounting for both positive and negative numbers and adding the relevant signs. **Integration** Calculations were initially tested with inputs from switches, then adjusted to work with the interface.	 Determinant for 2x2 Matrix  Determinant for 3x3 Matrix  Multiplication of 2x2 Matrices
Student B: Tze Yong Interface for multiply and determinant functions	 Flowcharts for multiply and determinant functions **Matrix size selection menu** shows a few options of matrix sizes. For the multiply function, the options of the second selection menu are restricted based on the size of the first matrix. Options that cannot be selected are greyed out. **Matrix editing screen** shows a matrix of the chosen size from the matrix size selection menu, with all terms set to 0. **Number pad screen** shows numbers 0 to 9 and a negative sign. Selecting a number updates the number on the right (see image). The negative sign	 Matrix size selection (left multiply, right determinant)  Matrix editing screen  Number pad screen

	toggles positive and negative, and can only be toggled when the number is non-zero. **Result screen** displays the final result of the multiply or determinant function. Controls: For all these screens, a **blue box** indicates the current choice. BTNU, BTNL, BTNR and BTND moves the box up, down, left and right respectively. BTNC selects the current choice. The function **will not end** when entered, until SW15 is on.	 Result screen (left multiply, right determinant)
Student C: Kong Kiat -Main Menu -Matrix Types Section -Hidden Features	Created the main menu page. Main menu has **green/white words cascading in the background** to mimic the “matrix rain” effect. A blue arrow shows the current selected feature. Users use **BTNU/BTND to toggle between the 4 options** and **BTNC to select the feature**. Turning SW15 on brings users from the individual features back to the main menu. Created Matrix Types section, which contains 3 pages on matrix basics (Basics), square matrices (Square) and diagonal matrices (Diagonal). Each page has a description as well as example(s). The controls are as follows: - BTNU/BTND: Toggle between description and examples - BTNL/BTNR: (When viewing descriptions) Toggle between Basics, Square and Diagonal (When viewing examples) Toggle between different examples. **Transition between Diagonal matrix examples is animated.** The screens contain arrows to indicate which buttons can be pressed for each page Implemented Hidden Features (Easter Eggs): - **Bullet Time:** By turning on the password of SW0,1,5 & 8 (1508) in the main menu, the user enters “bullet time”, where the **rain effect is in slow-motion**. - **Red Pill/Blue Pill:** - When the user gets a calculated determinant of 1999 (release year of The Matrix), the app goes to a screen prompting the user to pick between a red pill and blue pill. - BTNL/BTNR is used to toggle selection between red/blue pill, and BTNC is to select the pill. - Selecting the blue pill returns them to the select matrix size page, while selecting the red pill leads to the user “escaping the matrix”. (*Upon escaping the matrix, the user will not be able to leave the page. This is to portray the idea that the user has truly “escaped” the matrix)	 Matrix Rain Effect  Matrix Type Descriptions  Matrix Type Examples  Bullet Time Easter Egg  Red Pill/Blue Pill Easter Egg
Student D: Benjamin Quiz feature	Created the quiz, which has 5 T/F questions. The quiz questions are **pseudo-randomly selected** from a question bank of 10 questions. If the question goes offscreen, you can press BTNU/BTND to **scroll up/down**. Pressing BTNL/BTNR hovers over the True/False options, **highlighting the option** currently being selected. Pressing BTNC then **selects the corresponding option**. After selecting an answer, **a green tick or red cross** will appear on the screen for one second, representing correct or wrong respectively. After answering 5 questions, the **results screen will appear,** showing the score attained in the quiz. Users can then press BTNC to try the quiz again to try to beat your previous score. Controls: BTNL/BTNR: Hover over True/False options respectively BTNU/BTND: Scroll up/down question text, if applicable BTNC: Enter and select corresponding answer	 Quiz screen  Correct/Wrong screens  Results Scrolling down

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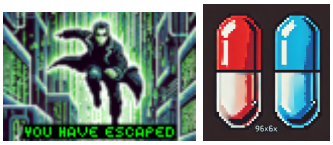
AI declaration

ChatGPT was used to find more efficient methods of instantiating similar modules. The output given was to use generate blocks with arrays. A modified example of usage of generate blocks is shown below. It is used to instantiate numbers in the matrix editing screen.

```
genvar i;
generate
    for (i = 0; i < 9; i = i + 1) begin: digits_block
        signed_dig_disp disp_i(
        .clk(clk), .curr_x(x_coord), .curr_y(y_coord),
        .left_x(NUMBER_LEFT_OFFSET + (3 - number_of_cols) * ((COL_LENGTH + COL_SPACING) / 2) + (i % 3) * (COL_LENGTH + COL_SPACING)),
        .top_y(NUMBER_TOP_OFFSET + (3 - number_of_rows) * ((ROW_HEIGHT + ROW_SPACING) / 2) + (i / 3) * (ROW_HEIGHT + ROW_SPACING)),
        .scale(2), .digit(num[i]), .isDigit(is_num[i])
        );
    end
endgenerate
```

ChatGPT was also used to generate art for the Red Pill/Blue Pill Easter Eggs.



Other References

A python script was used to convert images to bitmaps to be displayed on the OLED screen. The python script was adapted from
https://github.com/Hackin7/EE2026_Project_B-MODs/blob/main/Optimized_Image_Converter.py
Code to load graphics from Block RAM was adapted from
https://github.com/Hackin7/EE2026_Project_B-MODs / https://github.com/NicholasTanYY/fpga-project

Picture reference for letters and numbers
https://image.shutterstock.com/z/avopix-794215993.jpg

For pseudo-random number generator, formula for max-length LFSR taken from
https://docs.amd.com/v/u/en-US/xapp052

Feedback

The filename for the submission archive is unnecessarily long. We exceeded Windows maximum file name length when trying to unzip our file.