Cornell Duffield Engineering
School of Electrical and Computer Engineering

Development Board for RP2350 Pico2

With HDMI, DAC, Power Supply, and Keypad Interface

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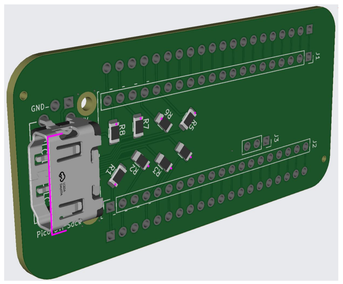


Abstract: We enabled HDMI video output on the Raspberry Pi Pico2 microcontroller board through progressive hardware and software development stages.

Key Words: Raspberry Pi Pico 2 (RP2350), Embedded System, DVI Sock, PCB Design, Real-Time Output

ECE 4760 would benefit from HDMI

The Raspberry Pi Pico 2 is a compact and mature microcontroller widely used in embedded development and educational projects. However, as a microcontroller, it does not natively support high-quality video output for large external displays. This project aims to enhance the Pico 2 platform by redesigning an existing PCB and adding high-speed video routing with an HDMI connector, allowing the board to output high-resolution video to an external display. A dedicated test program was also developed to verify and demonstrate the functionality of the system.

Now our Pico 2 supports DVI outputs!

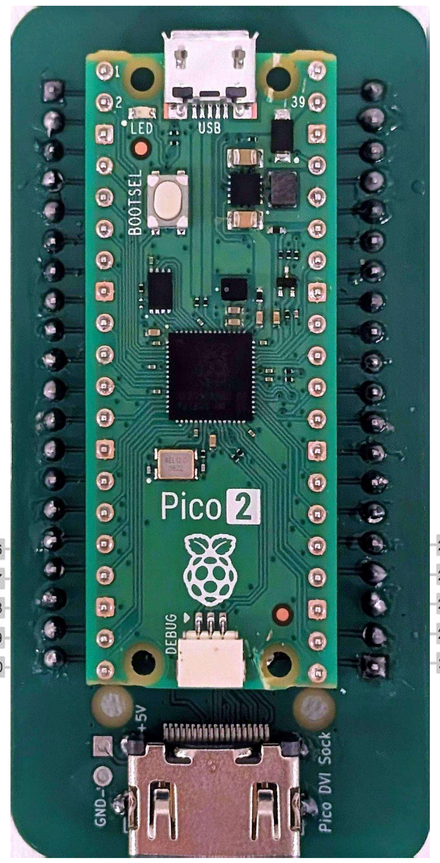
This project developed a custom RP2350-based Pico 2 development board that extends the capabilities of the Raspberry Pi Pico 2 by integrating HDMI/DVI video output support. The board also provides a foundation for future peripheral expansion, including DAC-based audio output, power supply circuitry, and keypad input. The overall goal was to create a more capable and compact embedded prototyping platform that reduces reliance on external expansion modules and improves usability for multimedia-oriented applications.

A simple board is cost-effective

The team selected a two-layer PCB structure instead of a more complex four-layer HDMI-style board to balance functionality, cost, simplicity, and manufacturability within the scope of a student project. Starting from an existing DVI Sock reference design, the hardware was adapted in KiCad to match the Pico 2 form factor. The design extended the pin header structure, preserved the TMDS-related video circuitry, and added layout improvements such as ground pours, keepout regions, mounting holes, and clearer connector mapping. The final result was a manufacturable prototype that supports the Pico 2 while routing the high-speed video signals required for external display output.

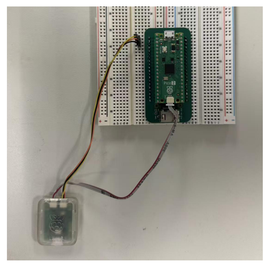
- *GPIO 14/15: CLK +/- signal: around 25 MHz (640×480@60 Hz)*
- *GPIO 12/13: Blue in RGB332: B[2:0]*
- *HSTX output (High-Speed TX)*
- *Data transfer: DMA Ping-Pong*
- *Hsync + Vsync (2 line) in TMDS*

UART0 TX	I2C0 SDA	SPI1 RX	GP12	16
UART0 RX	I2C0 SCL	SPI1 CSn	GP13	17
			GND	18
	I2C1 SDA	SPI1 SCK	GP14	19
	I2C1 SCL	SPI1 TX	GP15	20



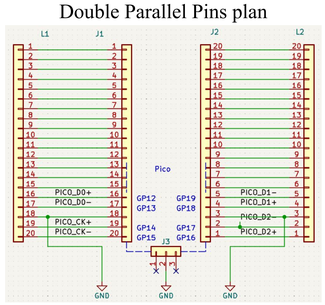
- *GPIO 18/19: Green in RGB332: G[2:0]*
- *GPIO 16/17: Red in RGB332: R[2:0]*

25	GP19	SPI0 TX	I2C1 SCL	
24	GP18	SPI0 SCK	I2C1 SDA	
23	GND			
22	GP17	SPI0 CSn	I2C0 SCL	UART0 RX
21	GP16	SPI0 RX	I2C0 SDA	UART0 TX



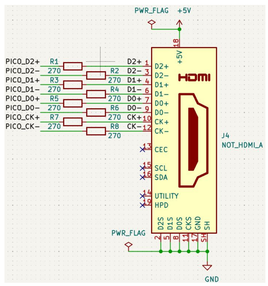
- *Breadboard*
- *Debugging port*
- *Microcontroller*
- *Monitor*
- *Laptop*

Schematic 1.
Double Parallel Pins plan

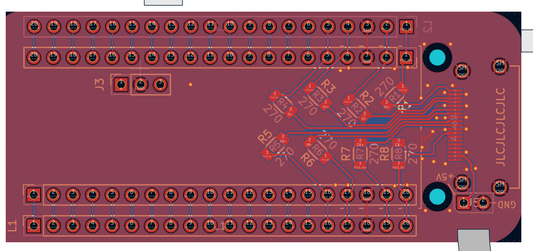


One dime for size reference

Schematic 2.
HDMI socket wiring and reststance

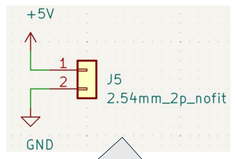


- HDMI 1.4
- Optimized resistance
- Paralleled ground
- JLC PCB footprint



PCB File. Integrated all of the parts together

Schematic 3. Isolated 5V and GND pins



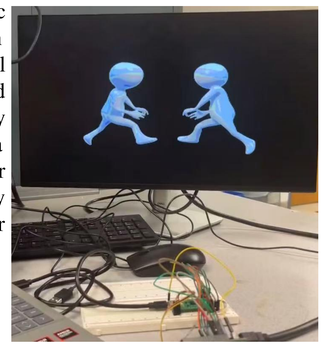
- Isolate to avoid noise interference
- Power efficient when IDLE

8 bit mountain indicates the big milestone

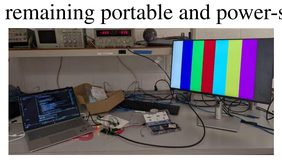
After basic colour display, we implemented a picture of a beautiful mountain, which was represented by 640 x 480 pixels. Using high speed HSTX differential output, we would be able to generate RGB signals across every corner of the monitor.

We can not only demonstrate images, but videos!

The mountain represents perfect static display. Moreover, we downloaded an open-source video and used a small Python script to split it into frames and play them on the monitor frame by frame. We could roughly achieve a frame rate at around 20 fps. The user interface was designed to display every possible video after the user places the video file in the folder.



With the MCP4822 module, audio output would be enabled. As we now have a perfect monitor, audio and processing units, we now have a real computer ready to work. It can handle a variety of light workloads while remaining portable and power-saving.



What else could we add..

The development board will be expanded beyond video output into a more complete embedded multimedia platform. Planned improvements include integrating a DAC and audio output path so the board can support basic sound generation and multimedia demonstrations, adding a more robust on-board power supply design to improve stability and reduce dependence on external wiring, and developing a simple user interface such as a keypad or button matrix for interactive control.

Reference

[1]Wren6991,“Pico-DVI-Sock”(GitHubrepository). Available:https://github.com/Wren6991/Pico-DVI-Sock . Accessed: Dec. 14, 2025.

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