Portable Gaming Console with ESP32-WROVER, TFT Display, and MicroSD Storage

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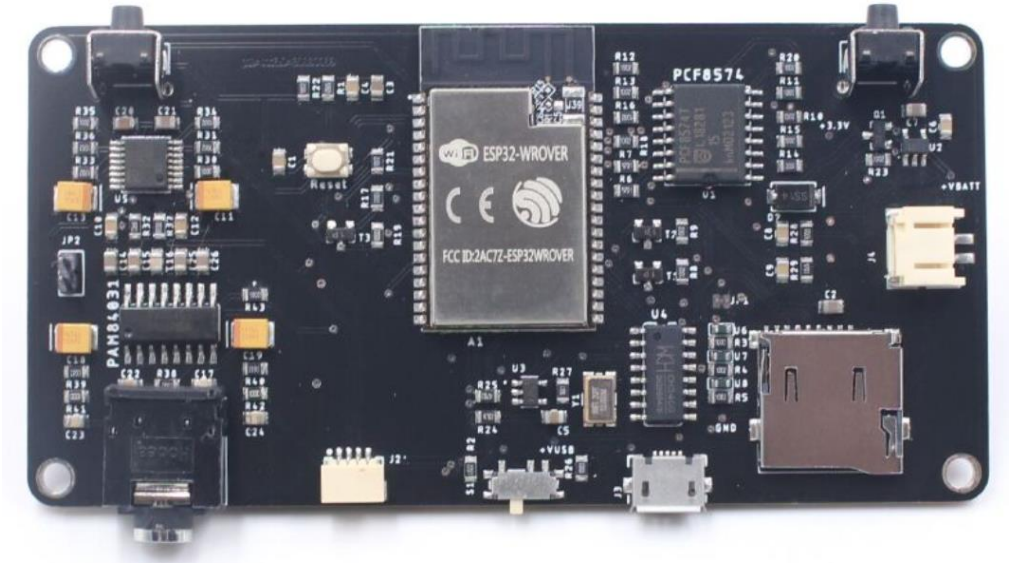
Summary

ArcadESP is an open-source, portable, retro video game console. Its main utility is to emulate games from classic consoles (such as the NES) using an ESP32 WROVER IE microcontroller, which is a very cheap and powerful chip. The main goal of the project is to leave it as a development board, which allows programming it for more functions.

3D View Reference:



ArcadESP: The Open-Source Retro Gaming Handheld

Description:

The circuit is centered on an ESP32-WROVER-I microcontroller. The main power supply for the system is 3.3V.

The design integrates several key peripherals for operation. It includes a TFT screen for graphics display, managed through multiple GPIO connections of the microcontroller. For user input, the system features a series of buttons, including direction controls (up, down, left, right), action buttons (Start, Select, A, B), and menu buttons, which connect to a PCF8574 I/O port expander.

Data storage is handled through a MicroSD card slot with push-out functionality, allowing the reading and writing of information. Additionally, the circuit incorporates an auto-reset section for the microcontroller. Test points (TP1, TP2, TP3, TP4) are also included for monitoring key voltages such as V_USB, V_BATT and 3.3V.

Resources:

USB-B	Power and data connector.
LTC4054	Integrated circuit for battery charging.
MIC5219 3.3v Regulator	Regulates and stabilizes the voltage to 3.3V.
ESP32 WROVER-I	The main microcontroller (the brain).
CH340	USB to serial converter for programming.
BUTTONS	Buttons for user interaction.
PCF8574 I/O Expander	Expands input/output pins for the buttons.
TFT Display	Screen for visual output.
Micro SD Card	Module for external storage.
Audio DAC UDA1334ATS	Converts digital audio to analog.
Amplifier PAM8403	Amplifies the audio signal for output.
Jack 3.5mm	Output connector for headphones or speakers.
LED Blue	Visual status indicator light.

Features:

Processing Core: ESP32-WROVER-IE N8R8 module with a dual-core CPU, Wi-Fi, Bluetooth, and integrated PSRAM.

Connectivity & Power: USB-B port for power and programming via an onboard CH340 USB-to-UART controller.

Power Management: Includes an LTC4054 Li-Ion battery charger and an MIC5219 LDO regulator for a stable 3.3V supply.

Audio Subsystem: Features an I2S Stereo DAC (UDA1334ATS), a PAM8403 Class-D amplifier, and a 3.5mm audio jack output.

User Interface: TFT color display for visual output, accompanied by user input buttons and a status LED.

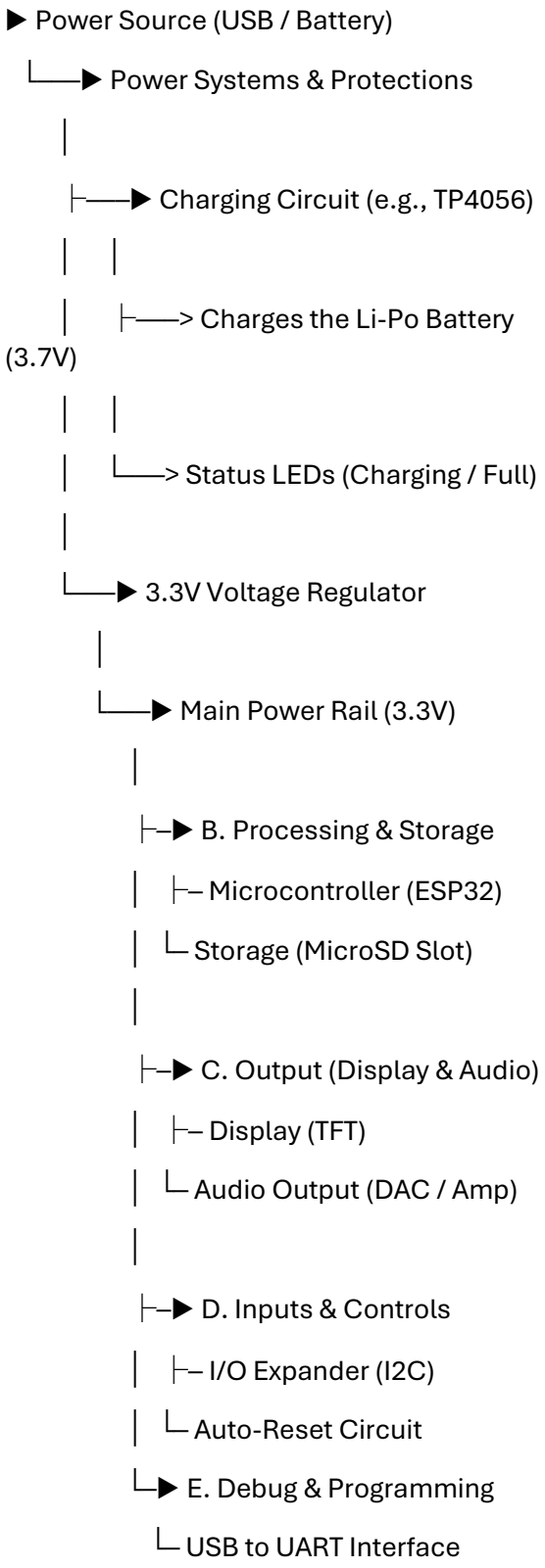
External Storage: Micro SD card slot for expandable data and media storage.

I/O Expansion: PCF8574 I/O expander to provide additional digital pins over the I2C bus.

Applications:

- Retro Emulation Console (Main Application)
- Portable Media Player
- IoT Device and Control Tool
- Development and Learning Platform (All in One)

Power Tree:



Input Source: Power originates from either a USB connection or a Li-Po Battery.

Charging & Protection: This input power feeds a charging circuit, which manages battery charging and provides a regulated output. This stage also powers the status LEDs.

Main Regulation: Power from the battery or charging circuit is routed to the 3.3V Voltage Regulator. This is the core of the power system, converting the variable battery voltage (typically 3.0V-4.2V) into a stable, constant 3.3V.

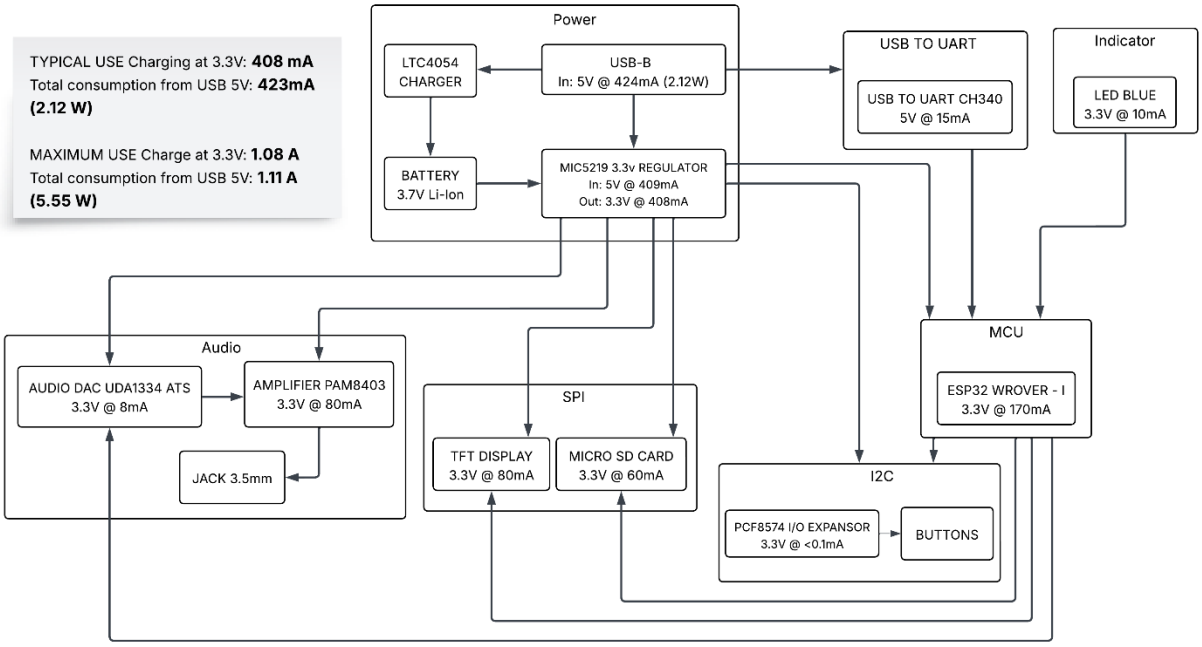
Distribution: The 3.3V rail distributes power to all active modules in the device: the microcontroller, display, audio circuitry, SD card slot, I/O expander, and the programming interface.

Power Budget:

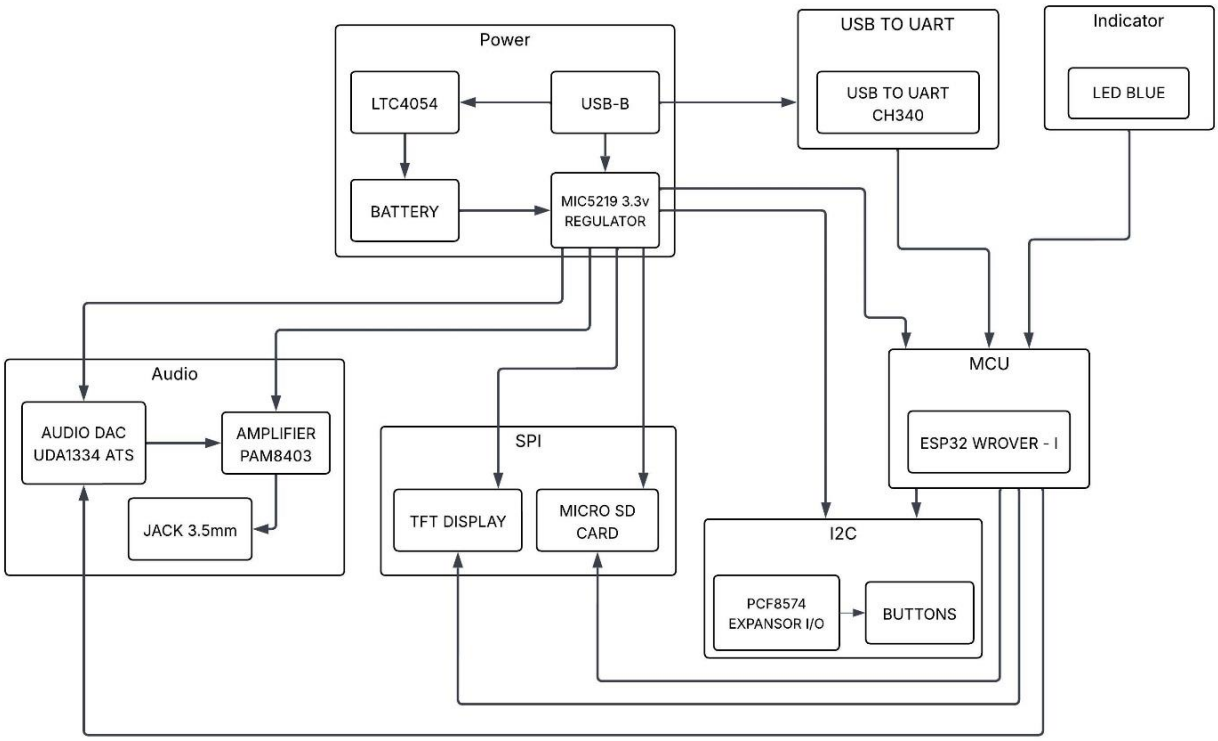
The system can be powered by a **USB** connection or a **Li-Po battery**. The input power goes through a protection and charging circuit. A central **3.3V voltage regulator** then takes this power and supplies a stable 3.3v to all the main components. These components include the **ESP32 microcontroller**, the **TFT display**, the **audio output**, the **MicroSD slot**, and the input/control circuits.

Typical Use: The device draws **423 mA (2.12 W)** from the 5V USB source for normal operation.

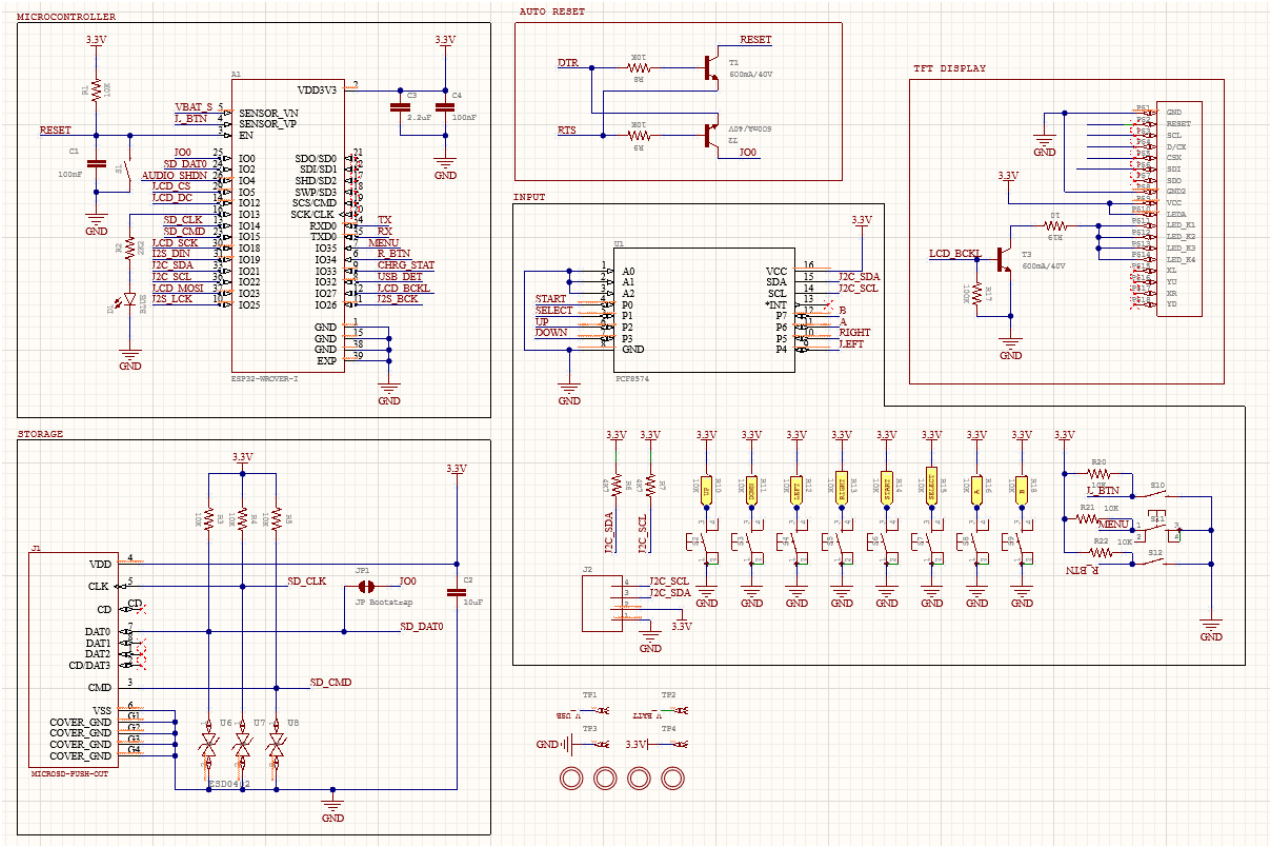
Maximum Use: Under heavy load (like using Wi-Fi), the draw spikes to **1.11 A (5.55 W)** from the 5V USB source.

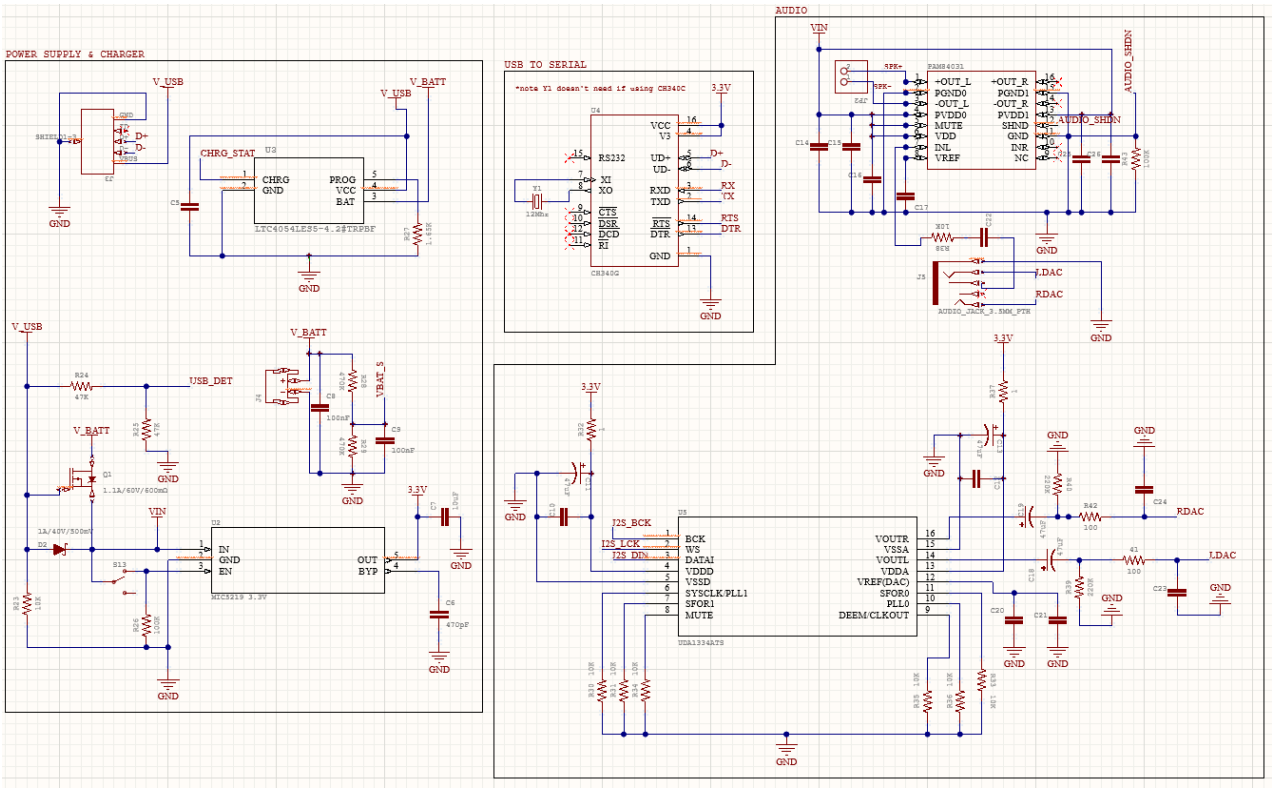


Block Diagram:

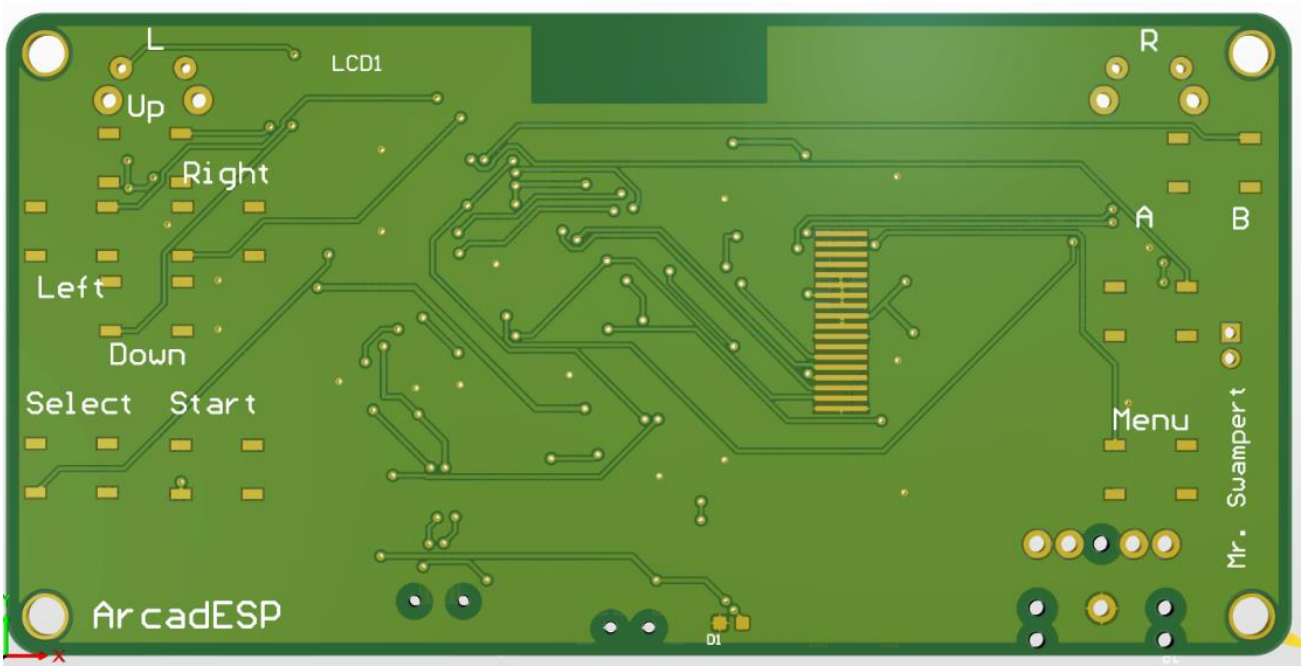


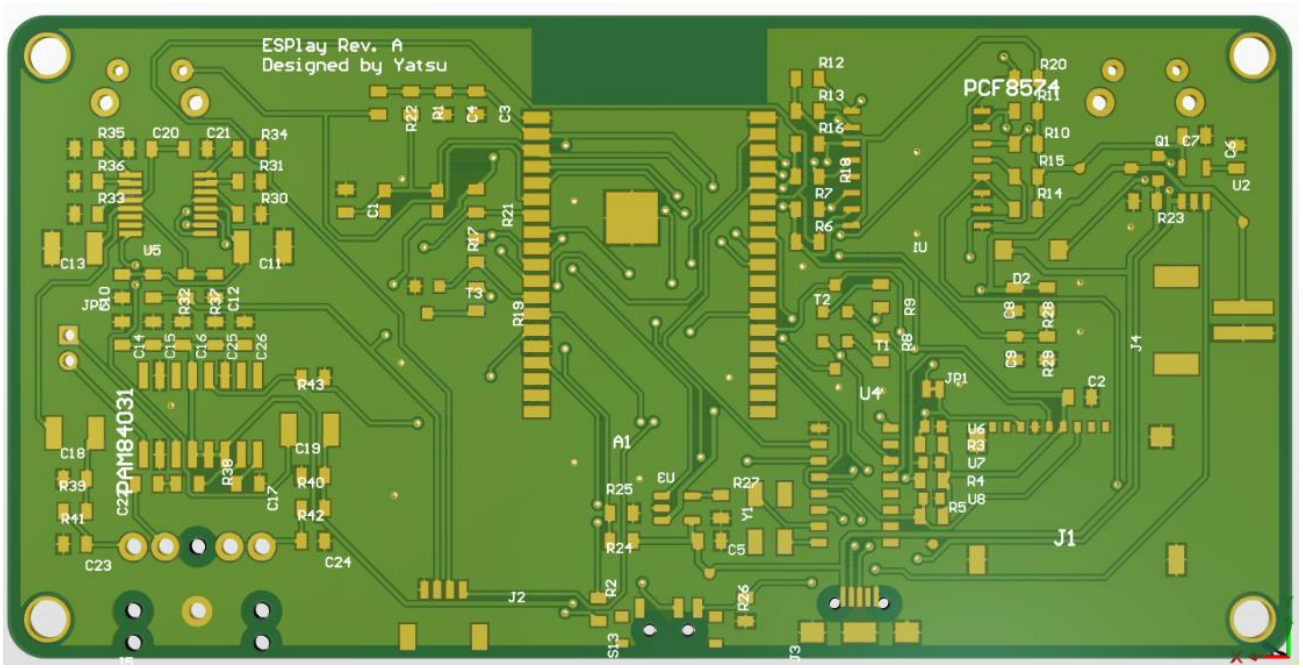
Schematic:


MICROCONTROLLER
AUTO RESET
TFT DISPLAY
INPUT
STORAGE
ESP32-WROVER-I
PCF8574
MICROSD-PUSH-OUT
JP Bootstrap


POWER SUPPLY & CHARGER
USB TO SERIAL
AUDIO
LTC4054LES5-4.2#TRPBF
CH340G
PAM8403
UDA1334ATS

3D Model Without Components:





The PCB is similar, but there are differences since the original idea is that it can be used as a development board.

Temperature:

Component	Category	Operating Temperature Range	Additional Notes
LTC4054	Battery Charger	0°C to 70°C (Guaranteed Performance)	The operating range extends from -40°C to 85°C. It has a thermal protection feature that reduces charging current if the internal temperature exceeds 120°C.
MIC5219	Voltage Regulator	-40°C to 125°C	This 3.3V regulator has a wide operating range, suitable for various environmental conditions.
ESP32 WROVER-I	MCU	-40°C to 85°C	Most ESP32-WROVER models operate in this range, making them robust for embedded applications.
PAM8403	Audio Amplifier	-40°C to 85°C	Includes over-temperature protection that shuts down the device if the internal temperature reaches 140°C.
CH340	USB to UART	-40°C to 85°C	This is the standard range for most variants of this converter chip.
PCF8574	I/O Expander	-40°C to 85°C	This component for input/output port expansion operates in a standard industrial range.
UDA1334A	Audio DAC	-20°C to 85°C	The digital-to-analog audio converter has a slightly more restricted operating range at the lower end compared to other components.
TFT Display	Display	Generally, 0°C to 50°C (Typical)	Exact ranges can vary depending on the manufacturer, but this is a common range for consumer TFT displays. Operation outside this range can affect visibility and lifespan.
Micro SD Card	Storage	-25°C to 85°C (Typical for Industrial Grade)	Consumer-grade cards may have a more limited range (e.g., 0°C to 70°C). The exact range depends on the specification of the card used.
Blue LED	Indicator	-40°C to 85°C (Typical)	Light-emitting diodes (LEDs) typically have a very wide operating range.

In Terms of Gaming:

It includes 11, YES eleven emulators, like **NES**, **Game Boy**, **Game Boy Color** and More.

Sector Focus:

The project is clearly focused on the maker or DIY sector. The target audience are:

Students and Electronics Hobbyists: People who want to put their hardware and software knowledge into practice.

Retro Gaming Enthusiasts: Nostalgic gamers who would enjoy not only playing but also building their own console.

Programmers and Developers: Those interested in developing software for embedded systems and optimizing code for hardware with limited resources. (For example, **PICO-8** is a virtual machine that emulates a video game console. While it is impossible to replicate with **ESP32**, there are alternatives such as **Fake-8**, which is the best open-source way to run **PICO-8** games on unsupported platforms).

This is not a product for the end consumer looking for an **"out-of-the-box"** console, but for someone who values the process of creation and customization.

The differential value of ArcadESP is its low cost, the versatile ESP32 and its open-source nature, which invites a community to modify, improve and share their own versions.

References:

Pebri, "GitHub - pebri86/esplay_micro_hardware: Micro version of esplay hardware, ESP32 based gaming console," *GitHub*. https://github.com/pebri86/esplay_micro_hardware

"ESPLay Micro V2," *Handheld ESP32 Game Console | Makerfabs*. https://www.makerfabs.com/esplay-micro-v2.html

Link to the repository where the files are hosted:

https://github.com/MrSwampert/Portable-Gaming-Console-with-ESP32