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-I 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.

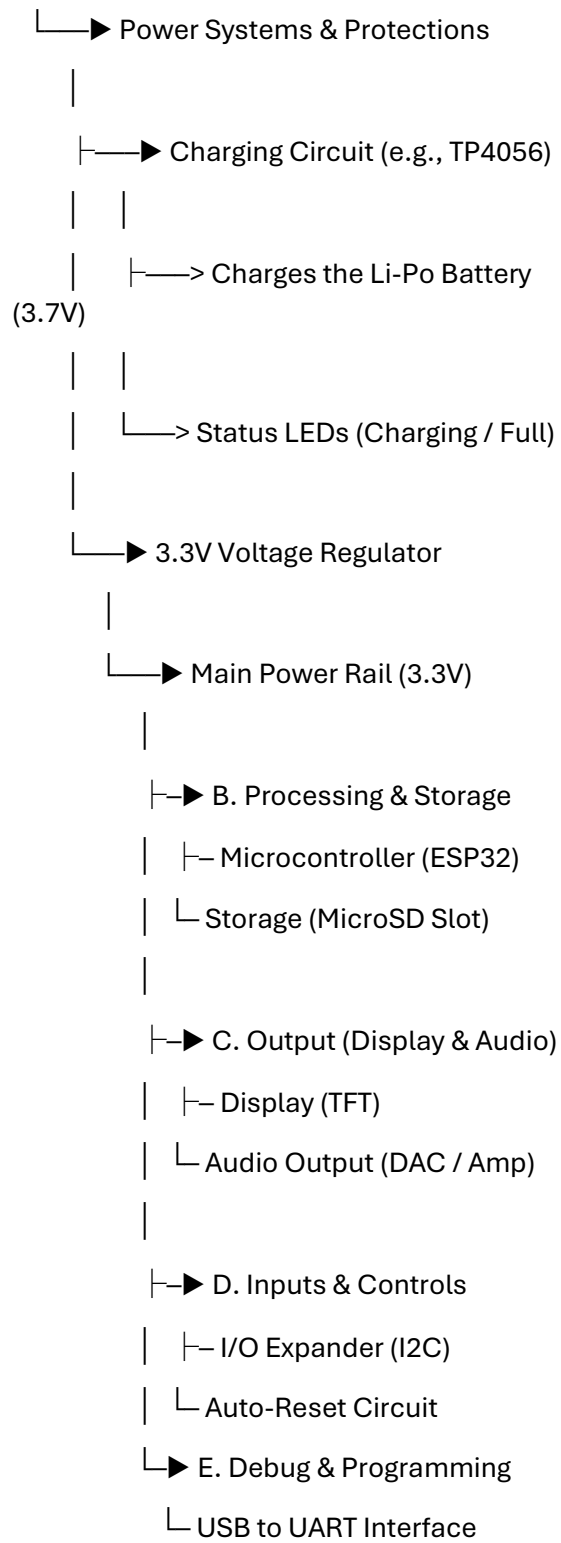External Storage: Micro SD card slot for expandable data and media storage.

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:

▶ Power Source (USB / Battery)

    └──▶ Power Systems & Protections

       │

       ├───▶ Charging Circuit (e.g., TP4056)

       │   │

       │   ├───> Charges the Li-Po Battery (3.7V)

       │   │

       │   └───> Status LEDs (Charging / Full)

       │

       └──▶ 3.3V Voltage Regulator

         │

         └──▶ Main Power Rail (3.3V)

           │

           ├─▶ B. Processing & Storage

           │ ├─ Microcontroller (ESP32)

           │ └─ Storage (MicroSD Slot)

           │

           ├─▶ C. Output (Display & Audio)

           │ ├─ Display (TFT)

           │ └─ Audio Output (DAC / Amp)

           │

           ├─▶ D. Inputs & Controls

           │ ├─ I/O Expander (I2C)

           │ └─ Auto-Reset Circuit

           └─▶ E. Debug & Programming

              └─ USB to UART Interface

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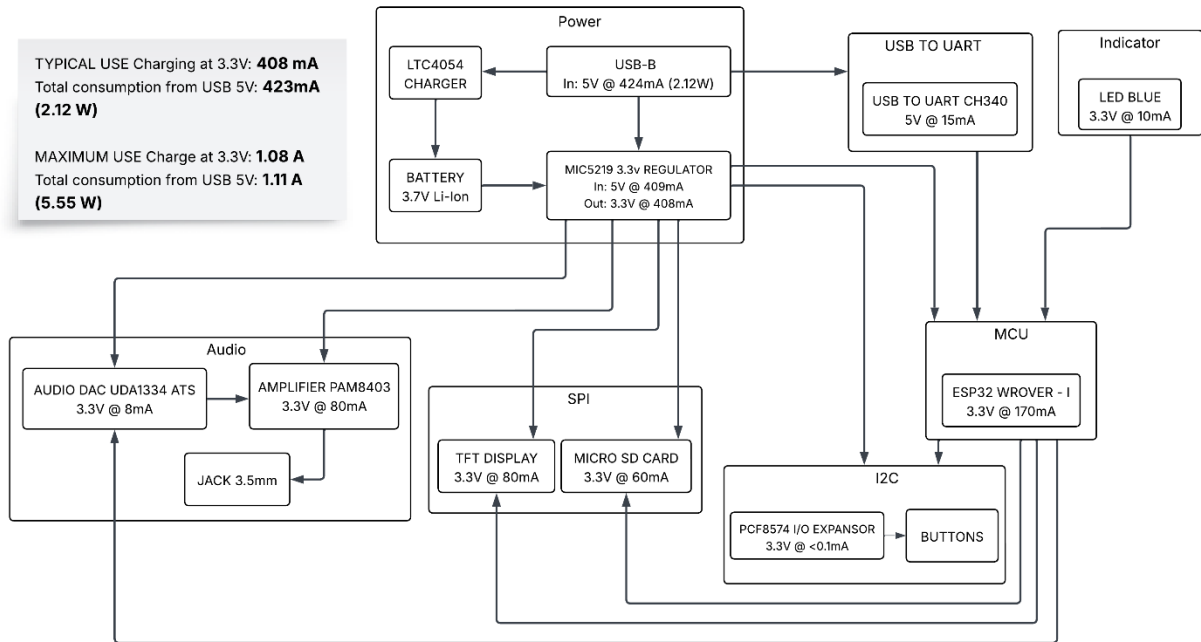
Distribution: The 3.3V rail distributes power to all active modules in the device: the microcontroller, display, audio circuitry, SD card slot, I/O expander, and the programming interface.
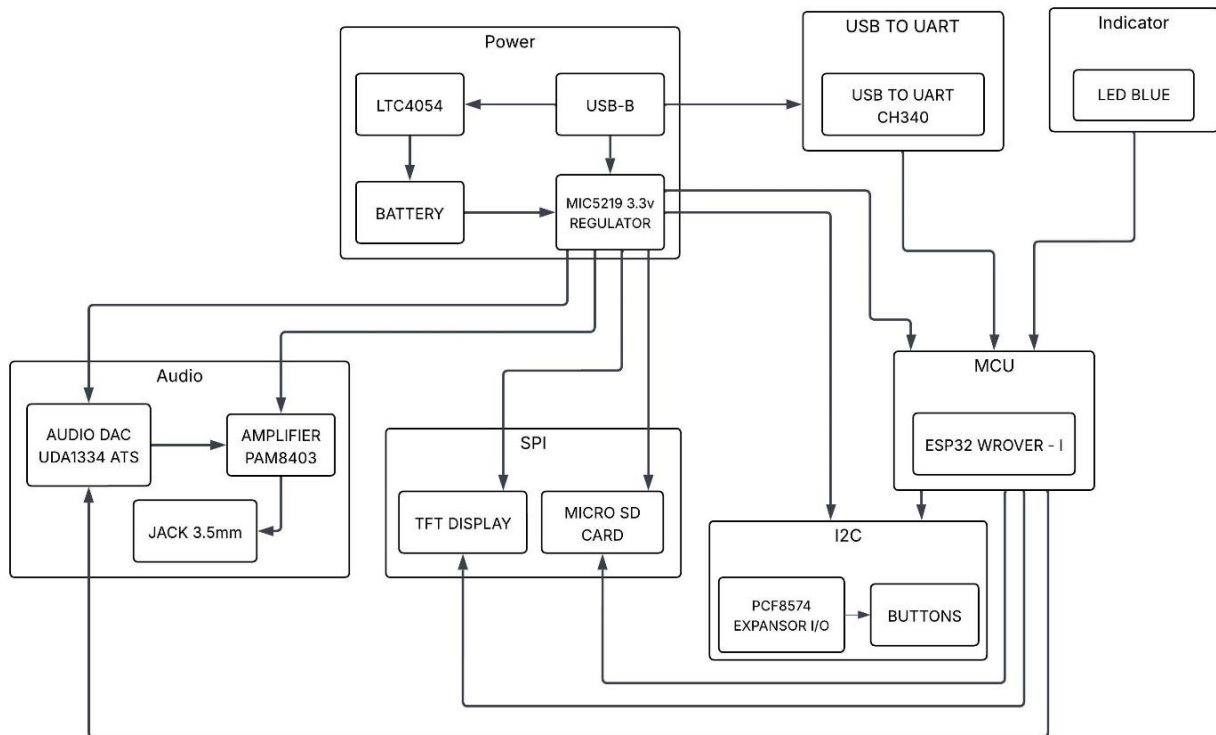
Power Budget:

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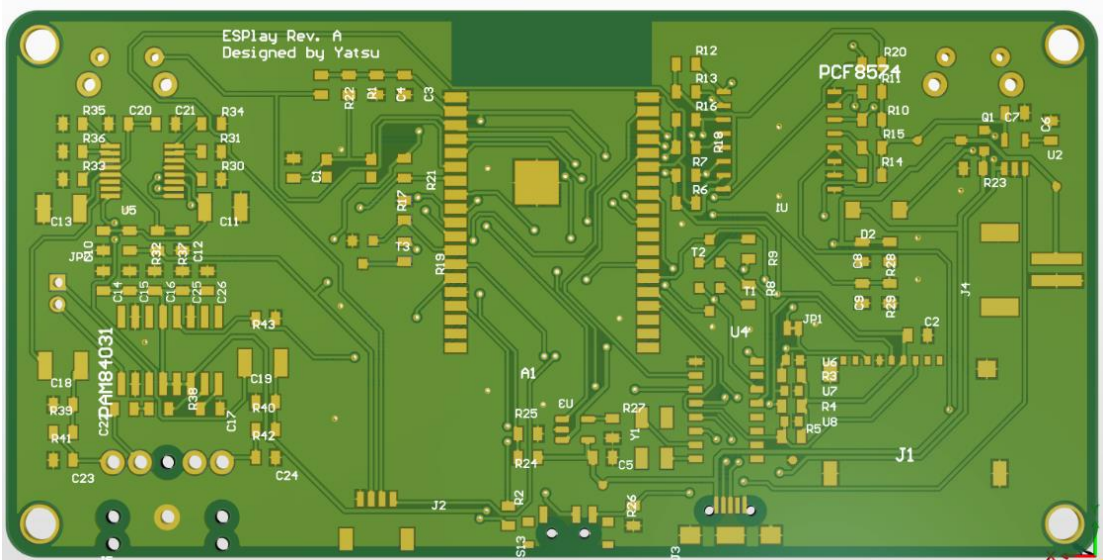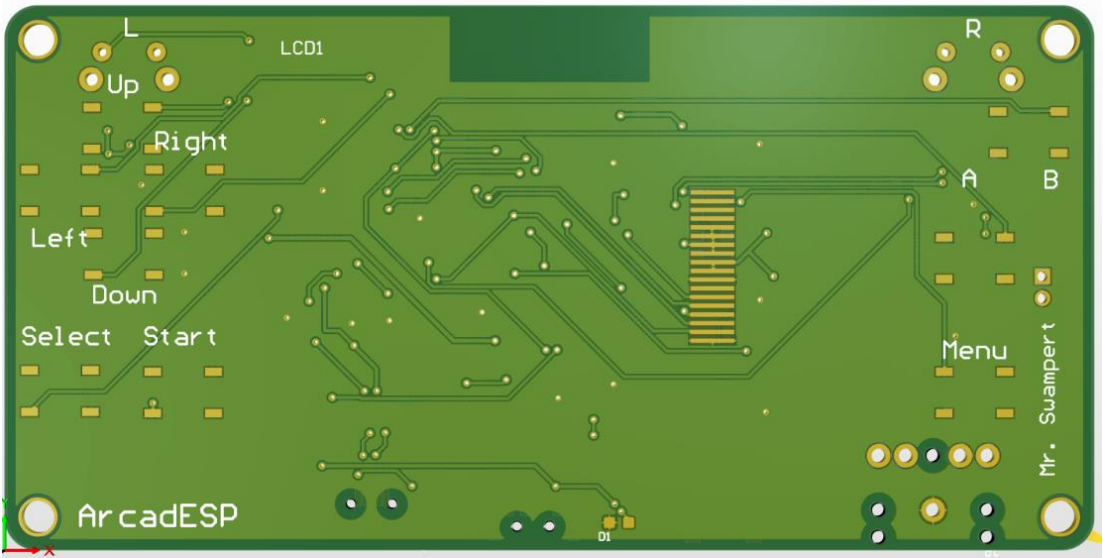
Maximum Use: Under heavy load (like using Wi-Fi), the draw spikes to **1.11 A (5.55 W)** from the 5V USB source.

TYPICAL USE Charging at 3.3V: **408 mA**
Total consumption from USB 5V: **423mA**
(2.12 W)

MAXIMUM USE Charge at 3.3V: **1.08 A**
Total consumption from USB 5V: **1.11 A**
(5.55 W)

Power

LTC4054
CHARGER

USB-B
In: 5V @ 424mA (2.12W)

BATTERY
3.7V Li-Ion

MIC5219 3.3v REGULATOR
In: 5V @ 409mA
Out: 3.3V @ 408mA

USB TO UART

USB TO UART CH340
5V @ 15mA

Indicator

LED BLUE
3.3V @ 10mA

MCU

ESP32 WROVER - I
3.3V @ 170mA

Audio

AUDIO DAC UDA1334 ATS
3.3V @ 8mA

AMPLIFIER PAM8403
3.3V @ 80mA

JACK 3.5mm

SPI

TFT DISPLAY
3.3V @ 80mA

MICRO SD CARD
3.3V @ 60mA

I2C

PCF8574 I/O EXPANSOR
3.3V @ <0.1mA

BUTTONS

Block Diagram:

Power

LTC4054

USB-B

BATTERY

MIC5219 3.3v
REGULATOR

USB TO UART

USB TO UART
CH340

Indicator

LED BLUE

MCU

ESP32 WROVER - I

Audio

AUDIO DAC
UDA1334 ATS

AMPLIFIER
PAM8403

JACK 3.5mm

SPI

TFT DISPLAY

MICRO SD
CARD

I2C

PCF8574
EXPANSOR I/O

BUTTONS

3D Model:

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.

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