# ESP32-S2

## esp-dev-kits Documentation

Release master
Espressif Systems
Dec 18, 2024

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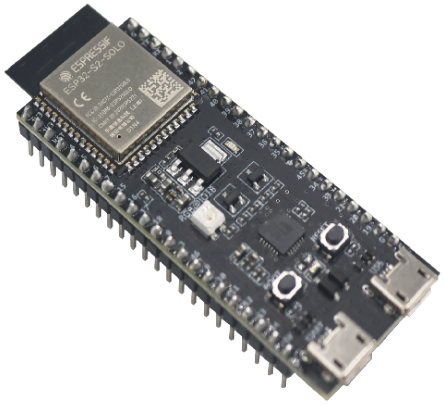
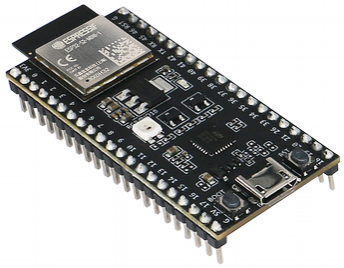
This document provides detailed user guides and examples for ESP32-S2 series development boards.

**Note:** For the full list of Espressif development boards, please go to ESP DevKits.

| **ESP32-S2 Development Boards** | |
|---|---|
|  |  |
| ESP32-S2-DevKitC-1 | ESP32-S2-DevKitM-1 |

# Chapter 1

# ESP32-S2-DevKitC-1

ESP32-S2-DevKitC-1 is an entry-level development board. This board integrates complete Wi-Fi functions. Most of the I/O pins are broken out to the pin headers on both sides for easy interfacing. Developers can either connect peripherals with jumper wires or mount ESP32-S2-DevKitC-1 on a breadboard.

## 1.1 ESP32-S2-DevKitC-1

This user guide will help you get started with ESP32-S2-DevKitC-1 and will also provide more in-depth information.

ESP32-S2-DevKitC-1 is an entry-level development board. This board integrates complete Wi-Fi functions. Most of the I/O pins are broken out to the pin headers on both sides for easy interfacing. Developers can either connect peripherals with jumper wires or mount ESP32-S2-DevKitC-1 on a breadboard.

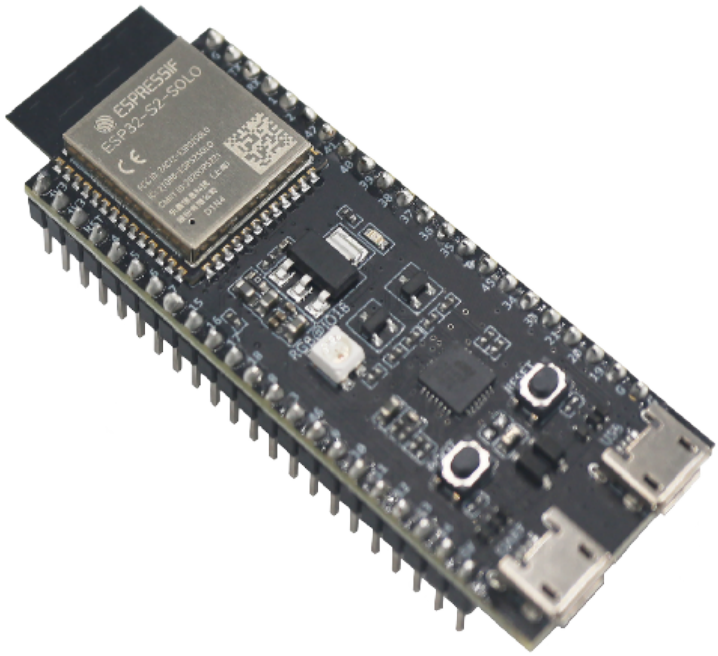



Fig. 1: ESP32-S2-DevKitC-1 with the ESP32-S2-SOLO Module

The document consists of the following major sections:

- *Getting Started*: Overview of ESP32-S2-DevKitC-1 and hardware/software setup instructions to get started.

- *Hardware Reference*: More detailed information about the ESP32-S2-DevKitC-1 ' s hardware.
- *Hardware Revision Details*: Revision history, known issues, and links to user guides for previous versions (if any) of ESP32-S2-DevKitC-1.
- *Related Documents*: Links to related documentation.

### 1.1.1 Getting Started

This section provides a brief introduction of ESP32-S2-DevKitC-1, instructions on how to do the initial hardware setup and how to flash firmware onto it.

#### Description of Components

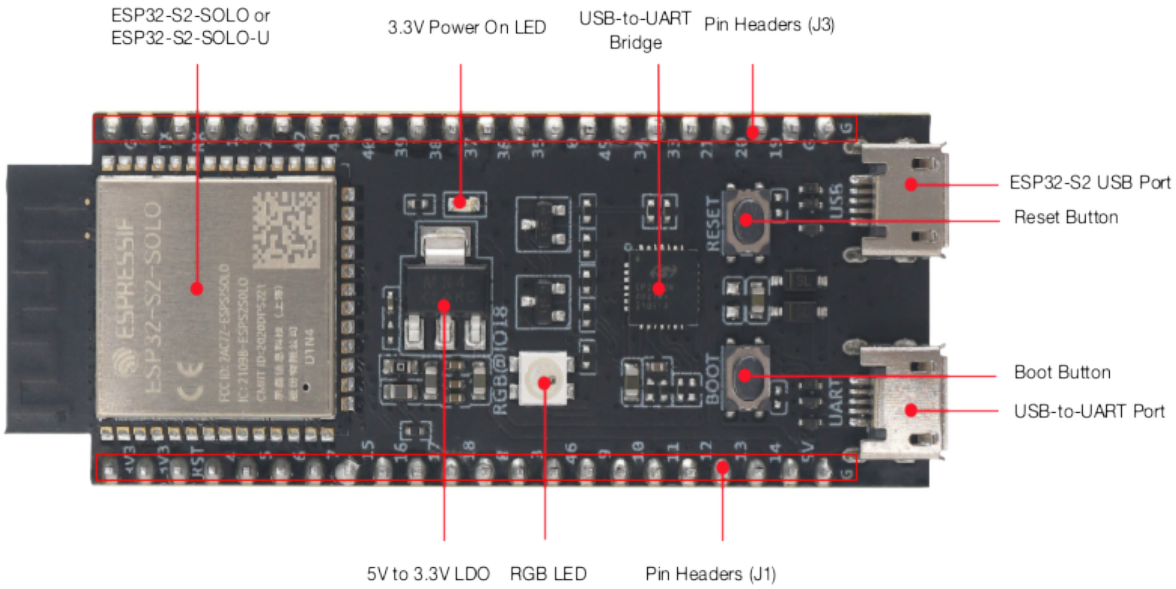



Fig. 2: ESP32-S2-DevKitC-1 - front

The key components of the board are described in a clockwise direction.

| Key Component | Description |
|---|---|
| On-board module (ESP32-S2-SOLO or ESP32-S2-SOLO-U in the above figure) | ESP32-S2-SOLO series modules with an on-board PCB antenna or a connector for an external antenna. This series of modules have multiple options for flash and PSRAM size. For more information, please refer to *Ordering Information*. |
| 3.3 V Power On LED | Turns on when the USB power is connected to the board. |
| USB-to-UART Bridge | Single USB-to-UART bridge chip provides transfer rates up to 3 Mbps. |
| Pin Headers | All available GPIO pins (except for the SPI bus for flash) are broken out to the pin headers on the board. For details, please see *Header Block*. |
| ESP32-S2 USB Port | ESP32-S2 full-speed USB OTG interface, compliant with the USB 1.1 specifications. The interface is used for power supply to the board, for flashing applications to the chip, and for communication with the chip using USB 1.1 protocols. |
| Reset Button | Press this button to restart the system. |
| Boot Button | Download button. Holding down **Boot** and then pressing **Reset** initiates Firmware Download mode for downloading firmware through the serial port. |
| USB-to-UART Port | A Micro-USB port used for power supply to the board, for flashing applications to the chip, as well as the communication with the chip via the on-board USB-to-UART bridge. |
| RGB LED | Addressable RGB LED, driven by GPIO18. |
| 5 V to 3.3 V LDO | Power regulator that converts a 5 V supply into a 3.3 V output. |

### Start Application Development

Before powering up your ESP32-S2-DevKitC-1, please make sure that it is in good condition with no obvious signs of damage.

### Required Hardware

- ESP32-S2-DevKitC-1
- USB 2.0 cable (Standard-A to Micro-B)
- Computer running Windows, Linux, or macOS

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**Note:** Be sure to use an appropriate USB cable. Some cables are for charging only and do not provide the needed data lines nor work for programming the boards.

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**Hardware Setup** Connect the board with the computer using **USB-to-UART Port** or **ESP32-S2 USB Port**. In subsequent steps, **USB-to-UART Port** will be used by default.

**Software Setup** Please proceed to Get Started, where Section Installation will quickly help you set up the development environment and then flash an application example into your ESP32-S2-DevKitC-1.

### Contents and Packaging

**Ordering Information** The development board has a variety of variants to choose from, as shown in the table below.

| Ordering Code | On-board Module | Flash | PSRAM | Antenna |
|---|---|---|---|---|
| ESP32-S2-DevKitC-1-N8R2 | ESP32-S2-SOLO-2 (Recommended) | 8 MB | 2 MB | PCB on-board antenna |
| ESP32-S2-DevKitC-1U-N8R2 | ESP32-S2-SOLO-2U (Recommended) | 8 MB | 2 MB | External antenna connector |
| ESP32-S2-DevKitC-1 (EOL) | ESP32-S2-SOLO (EOL) | 4 MB | — | PCB on-board antenna |
| ESP32-S2-DevKitC-1U (EOL) | ESP32-S2-SOLO-U (EOL) | 4 MB | — | External antenna connector |
| ESP32-S2-DevKitC-1R (EOL) | ESP32-S2-SOLO (EOL) | 4 MB | 2 MB | PCB on-board antenna |
| ESP32-S2-DevKitC-1RU (EOL) | ESP32-S2-SOLO-U (EOL) | 4 MB | 2 MB | External antenna connector |

**Retail Orders** If you order a few samples, each ESP32-S2-DevKitC-1 comes in an individual package in either antistatic bag or any packaging depending on your retailer.

For retail orders, please go to https://www.espressif.com/en/contact-us/get-samples.

**Wholesale Orders** If you order in bulk, the boards come in large cardboard boxes.

For wholesale orders, please go to https://www.espressif.com/en/contact-us/sales-questions.

### 1.1.2 Hardware Reference

#### Block Diagram

The block diagram below shows the components of ESP32-S2-DevKitC-1 and their interconnections.

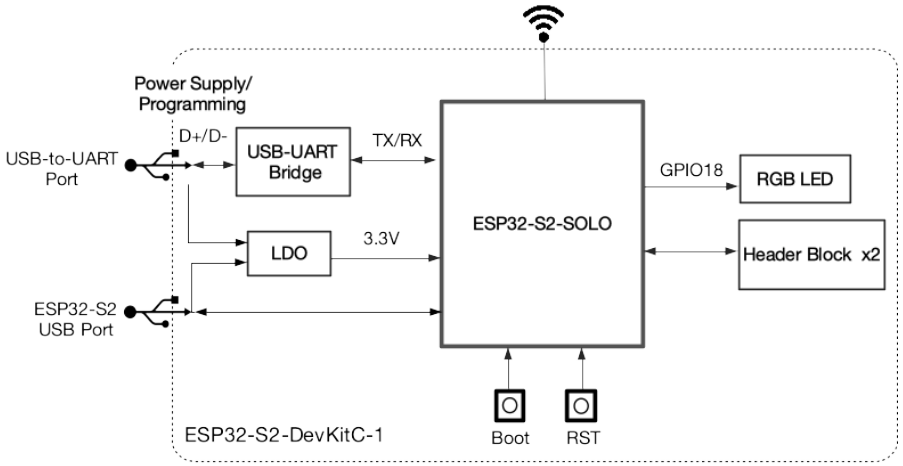



Fig. 3: ESP32-S2-DevKitC-1 (click to enlarge)

**Power Supply Options** There are three mutually exclusive ways to provide power to the board:

- USB-to-UART Port and ESP32-S2 USB Port (either one or both), default power supply (recommended)
- 5V and G (GND) pins
- 3V3 and G (GND) pins

### Header Block

The two tables below provide the **Name** and **Function** of the pin headers on both sides of the board (J1 and J3). The pin header names are shown in *ESP32-S2-DevKitC-1 - front*. The numbering is the same as in the ESP32-S2-DevKitC-1 Schematic (PDF).

**J1**

| No. | Name | Type[1] | Function |
|---|---|---|---|
| 1 | 3V3 | P | 3.3 V power supply |
| 2 | 3V3 | P | 3.3 V power supply |
| 3 | RST | I | CHIP_PU |
| 4 | 4 | I/O/T | RTC_GPIO4, GPIO4, TOUCH4, ADC1_CH3 |
| 5 | 5 | I/O/T | RTC_GPIO5, GPIO5, TOUCH5, ADC1_CH4 |
| 6 | 6 | I/O/T | RTC_GPIO6, GPIO6, TOUCH6, ADC1_CH5 |
| 7 | 7 | I/O/T | RTC_GPIO7, GPIO7, TOUCH7, ADC1_CH6 |
| 8 | 15 | I/O/T | RTC_GPIO15, GPIO15, U0RTS, ADC2_CH4, XTAL_32K_P |
| 9 | 16 | I/O/T | RTC_GPIO16, GPIO16, U0CTS, ADC2_CH5, XTAL_32K_N |
| 10 | 17 | I/O/T | RTC_GPIO17, GPIO17, U1TXD, ADC2_CH6, DAC_1 |
| 11 | 18[2] | I/O/T | RTC_GPIO18, GPIO18, U1RXD, ADC2_CH7, DAC_2, CLK_OUT3, RGB LED |
| 12 | 8 | I/O/T | RTC_GPIO8, GPIO8, TOUCH8, ADC1_CH7 |
| 13 | 3 | I/O/T | RTC_GPIO3, GPIO3, TOUCH3, ADC1_CH2 |
| 14 | 46 | I | GPIO46 |
| 15 | 9 | I/O/T | RTC_GPIO9, GPIO9, TOUCH9, ADC1_CH8, FSPIHD |
| 16 | 10 | I/O/T | RTC_GPIO10, GPIO10, TOUCH10, ADC1_CH9, FSPICS0, FSPIIO4 |
| 17 | 11 | I/O/T | RTC_GPIO11, GPIO11, TOUCH11, ADC2_CH0, FSPID, FSPIIO5 |
| 18 | 12 | I/O/T | RTC_GPIO12, GPIO12, TOUCH12, ADC2_CH1, FSPICLK, FSPIIO6 |
| 19 | 13 | I/O/T | RTC_GPIO13, GPIO13, TOUCH13, ADC2_CH2, FSPIQ, FSPIIO7 |
| 20 | 14 | I/O/T | RTC_GPIO14, GPIO14, TOUCH14, ADC2_CH3, FSPIWP, FSPIDQS |
| 21 | 5V | P | 5 V power supply |
| 22 | G | G | Ground |

[1] P: Power supply; I: Input; O: Output; T: High impedance.
[2] GPIO18 is not pulled up on boards with an ESP32-S2-SOLO-2 or ESP32-S2-SOLO-2U module.

**J3**

| No. | Name | Type | Function |
|---|---|---|---|
| 1 | G | G | Ground |
| 2 | TX | I/O/T | U0TXD, GPIO43, CLK_OUT1 |
| 3 | RX | I/O/T | U0RXD, GPIO44, CLK_OUT2 |
| 4 | 1 | I/O/T | RTC_GPIO1, GPIO1, TOUCH1, ADC1_CH0 |
| 5 | 2 | I/O/T | RTC_GPIO2, GPIO2, TOUCH2, ADC1_CH1 |
| 6 | 42 | I/O/T | MTMS, GPIO42 |
| 7 | 41 | I/O/T | MTDI, GPIO41, CLK_OUT1 |
| 8 | 40 | I/O/T | MTDO, GPIO40, CLK_OUT2 |
| 9 | 39 | I/O/T | MTCK, GPIO39, CLK_OUT3 |
| 10 | 38 | I/O/T | GPIO38, FSPIWP |
| 11 | 37 | I/O/T | SPIDQS, GPIO37, FSPIQ |
| 12 | 36 | I/O/T | SPIIO7, GPIO36, FSPICLK |
| 13 | 35 | I/O/T | SPIIO6, GPIO35, FSPID |
| 14 | 0 | I/O/T | RTC_GPIO0, GPIO0 |
| 15 | 45 | I/O/T | GPIO45 |
| 16 | 34 | I/O/T | SPIIO5, GPIO34, FSPICS0 |
| 17 | 33 | I/O/T | SPIIO4, GPIO33, FSPIHD |
| 18 | 21 | I/O/T | RTC_GPIO21, GPIO21 |
| 19 | 20 | I/O/T | RTC_GPIO20, GPIO20, U1CTS, ADC2_CH9, CLK_OUT1, USB_D+ |
| 20 | 19 | I/O/T | RTC_GPIO19, GPIO19, U1RTS, ADC2_CH8, CLK_OUT2, USB_D- |
| 21 | G | G | Ground |
| 22 | G | G | Ground |

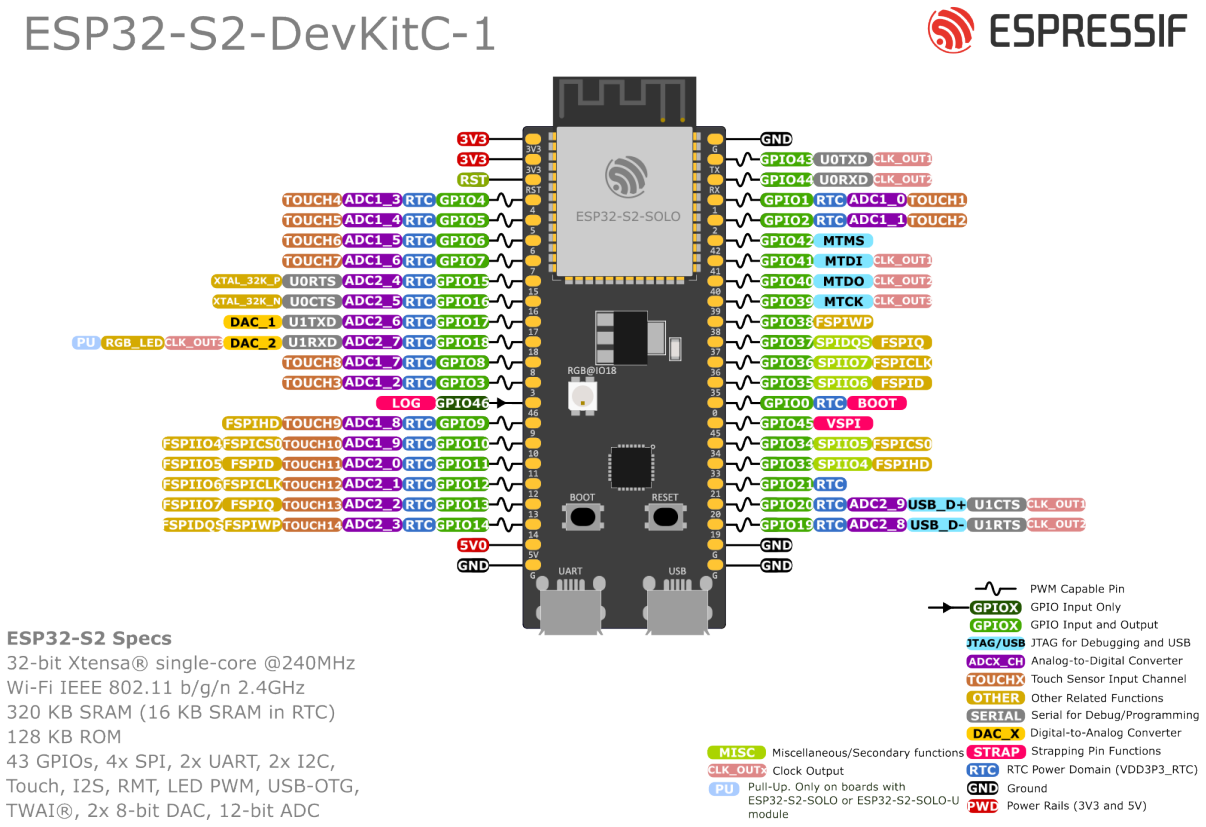



Fig. 4: ESP32-S2-DevKitC-1 Pin Layout (click to enlarge)

**Pin Layout**

### 1.1.3 Hardware Revision Details

This is the first revision of this board released.

### 1.1.4 Related Documents

- ESP32-S2 Series Chip Revision v1.0 Datasheet (PDF)
- ESP32-S2 Series Chip Revision v0.0 Datasheet (PDF)
- ESP32-S2 Series SoC Errata (PDF)
- ESP32-S2-SOLO-2 & ESP32-S2-SOLO-2U Module Datasheet (PDF)
- ESP32-S2-SOLO & ESP32-S2-SOLO-U Module Datasheet (PDF)
- ESP32-S2-DevKitC-1 Schematic (PDF)
- ESP32-S2-DevKitC-1 PCB Layout (PDF)
- ESP32-S2-DevKitC-1 Dimensions (PDF)
- ESP32-S2-DevKitC-1 Dimensions source file (DXF) - You can view it with Autodesk Viewer online

For further design documentation for the board, please contact us at sales@espressif.com.

# Chapter 2

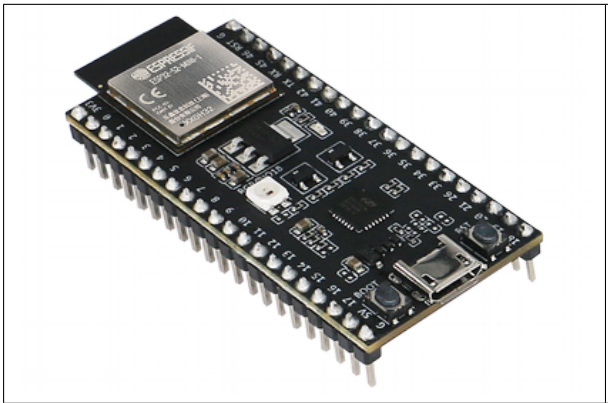
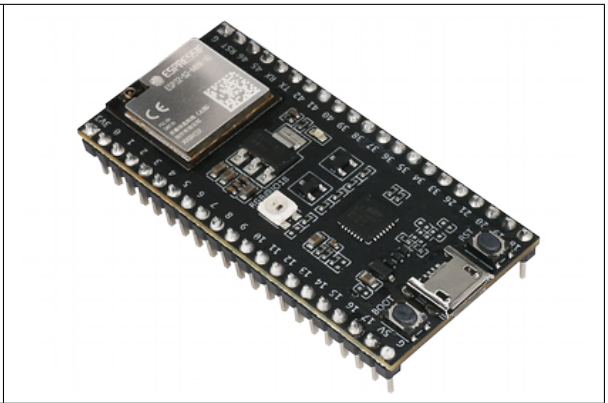
# ESP32-S2-DevKitM-1

ESP32-S2-DevKitM-1 is entry-level development board. Most of the I/O pins on the module are broken out to the pin headers on both sides for easy interfacing. Developers can either connect peripherals with jumper wires or mount ESP32-S2-DevKitM-1 on a breadboard.

## 2.1 ESP32-S2-DevKitM-1

This user guide provides information on Espressif ' s small-sized development board ESP32-S2-DevKitM-1.

ESP32-S2-DevKitM-1 is entry-level development board. Most of the I/O pins on the module are broken out to the pin headers on both sides for easy interfacing. Developers can either connect peripherals with jumper wires or mount ESP32-S2-DevKitM-1 on a breadboard.

| | |
|---|---|
|  |  |
| ESP32-S2-DevKitM-1 | ESP32-S2-DevKitM-1U |

The document consists of the following major sections:

- *Getting started*: Provides an overview of the ESP32-S2-DevKitM-1 and hardware/software setup instructions to get started.
- *Hardware reference*: Provides more detailed information about the ESP32-S2-DevKitM-1 ' s hardware.
- *Hardware Revision Details*: Revision history, known issues, and links to user guides for previous versions (if any) of ESP32-S2-DevKitM-1.
- *Related Documents*: Gives links to related documentation.

### 2.1.1 Getting Started

This section describes how to get started with ESP32-S2-DevKitM-1. It begins with a few introductory sections about the ESP32-S2-DevKitM-1, then Section *Start Application Development* provides instructions on how to get the ESP32-S2-DevKitM-1 ready and flash firmware into it.

#### Contents and Packaging

**Ordering Information** The development board has a variety of variants to choose from, as shown in the table below.

| Ordering Code | On-board Module | Flash | PSRAM | Antenna |
|---|---|---|---|---|
| ESP32-S2-DevKitM-1-N4R2 | ESP32-S2-MINI-2 (Recommended) | 4 MB | 2 MB | PCB on-board antenna |
| ESP32-S2-DevKitM-1U-N4R2 | ESP32-S2-MINI-2U (Recommended) | 4 MB | 2 MB | External antenna connector |
| ESP32-S2-DevKitM-1 (EOL) | ESP32-S2-MINI-1 (EOL) | 4 MB | — | PCB on-board antenna |
| ESP32-S2-DevKitM-1U (EOL) | ESP32-S2-MINI-1U (EOL) | 4 MB | — | External antenna connector |
| ESP32-S2-DevKitM-1R (EOL) | ESP32-S2-MINI-1 (EOL) | 4 MB | 2 MB | PCB on-board antenna |
| ESP32-S2-DevKitM-1RU (EOL) | ESP32-S2-MINI-1U (EOL) | 4 MB | 2 MB | External antenna connector |

**Retail Orders** If you order a few samples, each ESP32-S2-DevKitM-1 comes in an individual package in either antistatic bag or any packaging depending on your retailer.

For retail orders, please go to https://www.espressif.com/en/contact-us/get-samples.

**Wholesale Orders** If you order in bulk, the boards come in large cardboard boxes.

For wholesale orders, please go to https://www.espressif.com/en/contact-us/sales-questions.

#### Description of Components

The key components of the board are described in a clockwise direction.

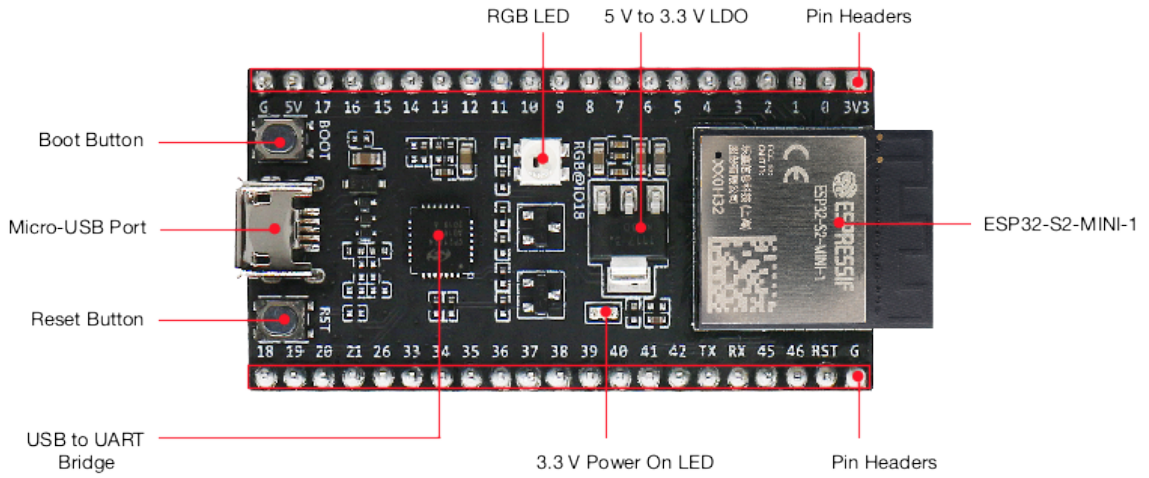



Fig. 1: ESP32-S2-DevKitM-1 - front

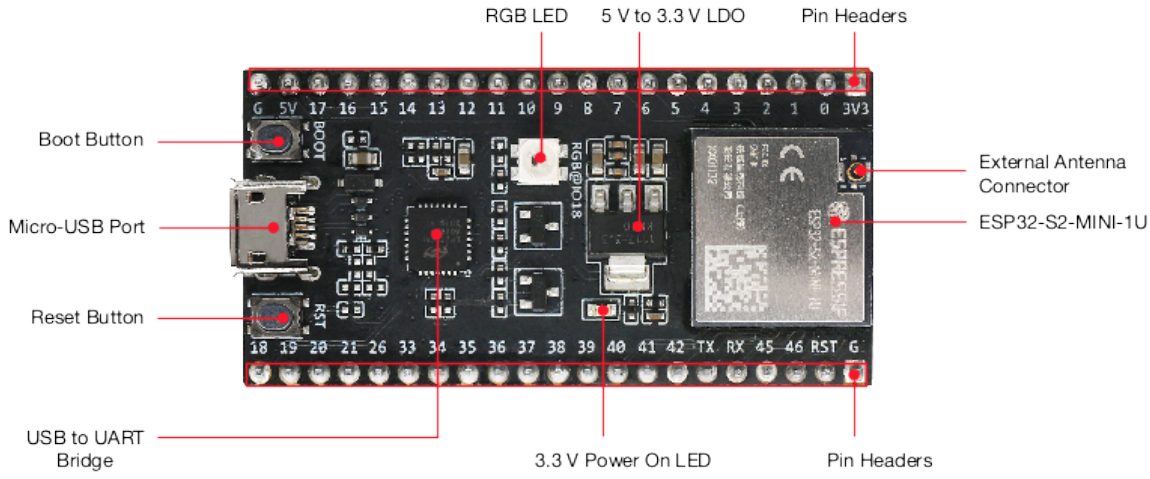



Fig. 2: ESP32-S2-DevKitM-1U - front

| Key Component | Description |
|---|---|
| On-board module (ESP32-S2-MINI-1 or ESP32-S2-MINI-1U in figures above) | ESP32-S2-MINI series modules with an on-board PCB antenna or a connector for an external antenna. This series of modules, known for its small size, have a flash and/or a PSRAM integrated in the chip package. For more information, please refer to *Ordering Information*. |
| Pin Headers | All available GPIO pins (except for the SPI bus for flash) are broken out to the pin headers on the board. Users can program ESP32-S2FH4 chip to enable multiple functions such as SPI, I2S, UART, I2C, touch sensors, PWM etc. For details, please see *Header Block*. |
| 3.3 V Power On LED | Turns on when the USB power is connected to the board. |
| USB to UART Bridge | Single USB-UART bridge chip provides transfer rates up to 3 Mbps. |
| Reset Button | Reset button. |
| Micro-USB Port | USB interface. Power supply for the board as well as the communication interface between a computer and the ESP32-S2FH4 chip. |
| Boot Button | Download button. Holding down **Boot** and then pressing **Reset** initiates Firmware Download mode for downloading firmware through the serial port. |
| RGB LED | Addressable RGB LED, driven by GPIO18. |
| 5 V to 3.3 V LDO | Power regulator that converts a 5 V supply into a 3.3 V output. |
| External Antenna Connector | On **ESP32-S2-MINI-2U** and **ESP32-S2-MINI-1U** module only. For connector dimensions, please refer to Section External Antenna Connector Dimensions in module datasheet. |

#### Start Application Development

Before powering up your ESP32-S2-DevKitM-1, please make sure that it is in good condition with no obvious signs of damage.

#### Required Hardware

- ESP32-S2-DevKitM-1
- USB 2.0 cable (Standard-A to Micro-B)
- Computer running Windows, Linux, or macOS

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**Note:** Be sure to use an appropriate USB cable. Some cables are for charging only and do not provide the needed data lines nor work for programming the boards.

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**Software Setup** Please proceed to Get Started, where Section Installation will quickly help you set up the development environment and then flash an application example into your ESP32-S2-DevKitM-1.

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**Note:** ESP32-S2 series of chips only is only supported in ESP-IDF master or version v4.2 and higher.

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### 2.1.2 Hardware Reference

#### Block Diagram

A block diagram below shows the components of ESP32-S2-DevKitM-1 and their interconnections.

**Power Supply Options** There are three mutually exclusive ways to provide power to the board:

- Micro-USB Port, default power supply
- 5V and GND pin headers

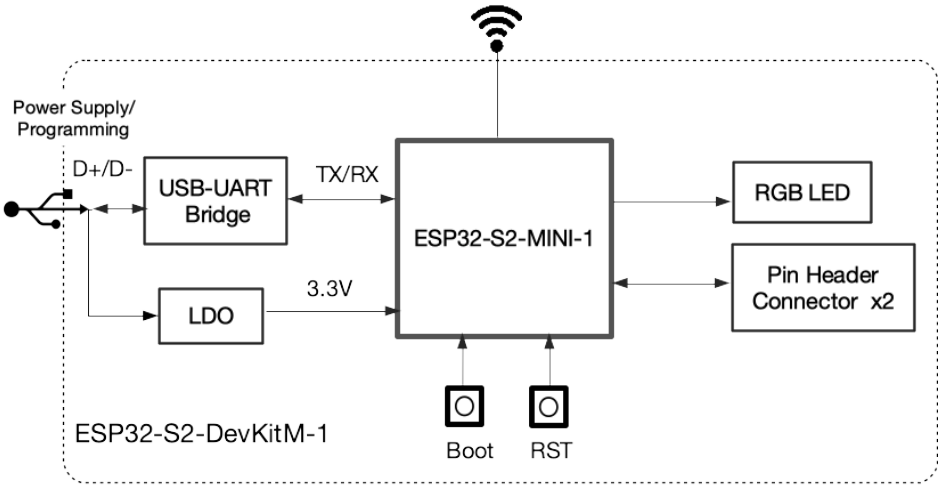



Fig. 3: ESP32-S2-DevKitM-1 (click to enlarge)

- 3V3 and GND pin headers

It is recommended to use the first option: micro USB Port.

### Header Block

The two tables below provide the **Name** and **Function** of the pin headers on both sides of the board (J1 and J3). The pin header names are shown in *ESP32-S2-DevKitM-1 - front*. The numbering is the same as in the ESP32-S2-DevKitM-1 Schematics (PDF).

**J1**

| No. | Name | Type[1] | Function |
|---|---|---|---|
| 1 | 3V3 | P | 3.3 V power supply |
| 2 | 0 | I/O/T | RTC_GPIO0, GPIO0 |
| 3 | 1 | I/O/T | RTC_GPIO1, GPIO1, TOUCH1, ADC1_CH0 |
| 4 | 2 | I/O/T | RTC_GPIO2, GPIO2, TOUCH2, ADC1_CH1 |
| 5 | 3 | I/O/T | RTC_GPIO3, GPIO3, TOUCH3, ADC1_CH2 |
| 6 | 4 | I/O/T | RTC_GPIO4, GPIO4, TOUCH4, ADC1_CH3 |
| 7 | 5 | I/O/T | RTC_GPIO5, GPIO5, TOUCH5, ADC1_CH4 |
| 8 | 6 | I/O/T | RTC_GPIO6, GPIO6, TOUCH6, ADC1_CH5 |
| 9 | 7 | I/O/T | RTC_GPIO7, GPIO7, TOUCH7, ADC1_CH6 |
| 10 | 8 | I/O/T | RTC_GPIO8, GPIO8, TOUCH8, ADC1_CH7 |
| 11 | 9 | I/O/T | RTC_GPIO9, GPIO9, TOUCH9, ADC1_CH8, FSPIHD |
| 12 | 10 | I/O/T | RTC_GPIO10, GPIO10, TOUCH10, ADC1_CH9, FSPICS0, FSPIIO4 |
| 13 | 11 | I/O/T | RTC_GPIO11, GPIO11, TOUCH11, ADC2_CH0, FSPID, FSPIIO5 |
| 14 | 12 | I/O/T | RTC_GPIO12, GPIO12, TOUCH12, ADC2_CH1, FSPICLK, FSPIIO6 |
| 15 | 13 | I/O/T | RTC_GPIO13, GPIO13, TOUCH13, ADC2_CH2, FSPIQ, FSPIIO7 |
| 16 | 14 | I/O/T | RTC_GPIO14, GPIO14, TOUCH14, ADC2_CH3, FSPIWP, FSPIDQS |
| 17 | 15 | I/O/T | RTC_GPIO15, GPIO15, U0RTS, ADC2_CH4, XTAL_32K_P |
| 18 | 16 | I/O/T | RTC_GPIO16, GPIO16, U0CTS, ADC2_CH5, XTAL_32K_N |
| 19 | 17 | I/O/T | RTC_GPIO17, GPIO17, U1TXD, ADC2_CH6, DAC_1 |
| 20 | 5V | P | 5 V power supply |
| 21 | G | G | Ground |

[1] P: Power supply; I: Input; O: Output; T: High impedance.

### J3

| No. | Name | Type | Function |
|---|---|---|---|
| 1 | G | G | Ground |
| 2 | RST | I | CHIP_PU |
| 3 | 46 | I | GPIO46 |
| 4 | 45 | I/O/T | GPIO45 |
| 5 | RX | I/O/T | U0RXD, GPIO44, CLK_OUT2 |
| 6 | TX | I/O/T | U0TXD, GPIO43, CLK_OUT1 |
| 7 | 42 | I/O/T | MTMS, GPIO42 |
| 8 | 41 | I/O/T | MTDI, GPIO41, CLK_OUT1 |
| 9 | 40 | I/O/T | MTDO, GPIO40, CLK_OUT2 |
| 10 | 39 | I/O/T | MTCK, GPIO39, CLK_OUT3 |
| 11 | 38 | I/O/T | GPIO38, FSPIWP |
| 12 | 37 | I/O/T | SPIDQS, GPIO37, FSPIQ |
| 13 | 36 | I/O/T | SPIIO7, GPIO36, FSPICLK |
| 14 | 35 | I/O/T | SPIIO6, GPIO35, FSPID |
| 15 | 34 | I/O/T | SPIIO5, GPIO34, FSPICS0 |
| 16 | 33 | I/O/T | SPIIO4, GPIO33, FSPIHD |
| 17 | 26 | I/O/T | SPICS1, GPIO26 |
| 18 | 21 | I/O/T | RTC_GPIO21, GPIO21 |
| 19 | 20 | I/O/T | RTC_GPIO20, GPIO20, U1CTS, ADC2_CH9, CLK_OUT1, USB_D+ |
| 20 | 19 | I/O/T | RTC_GPIO19, GPIO19, U1RTS, ADC2_CH8, CLK_OUT2, USB_D- |
| 21 | 18 | I/O/T | RTC_GPIO18, GPIO18, U1RXD, ADC2_CH7, DAC_2, CLK_OUT3, RGB LED |

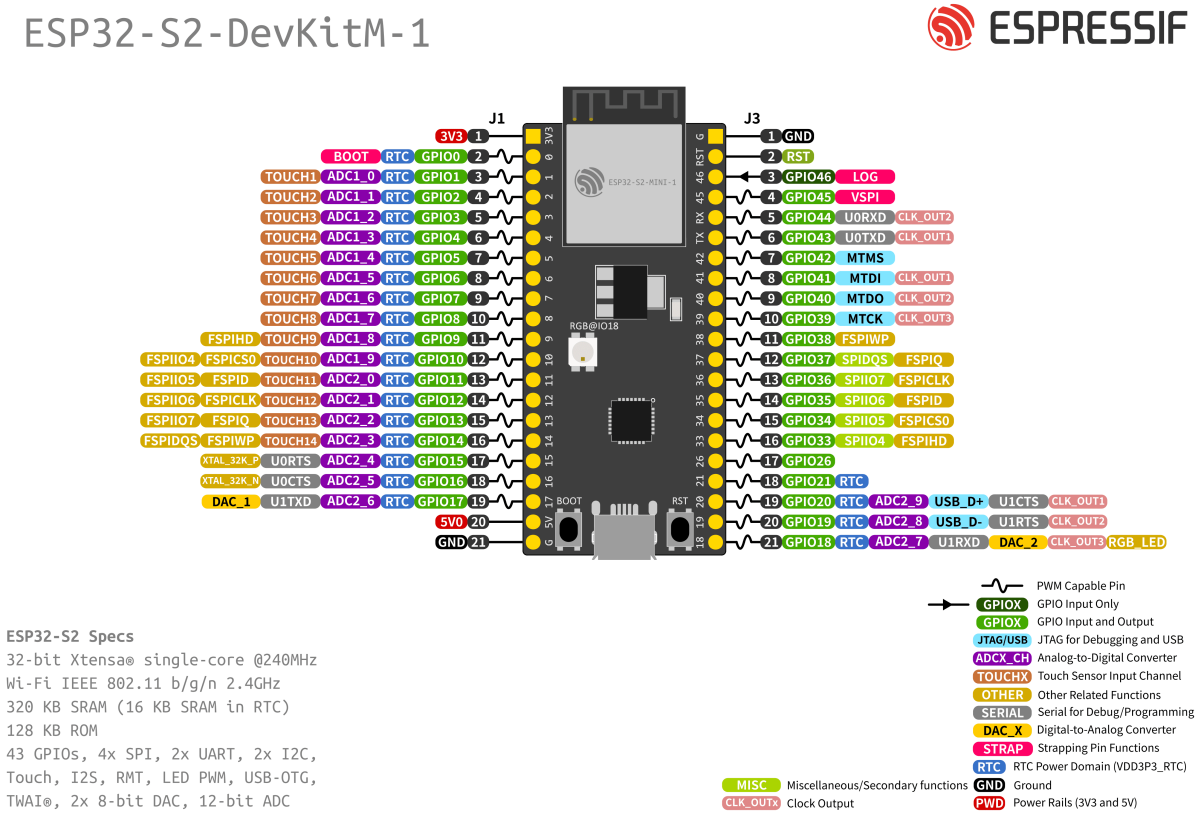



Fig. 4: ESP32-S2-DevKitM-1 Pin Layout (click to enlarge)

## Pin Layout

### 2.1.3 Hardware Revision Details

This is the first revision of this board released.

### 2.1.4 Related Documents

- ESP32-S2 Series Chip Revision v1.0 Datasheet (PDF)
- ESP32-S2 Series Chip Revision v0.0 Datasheet (PDF)
- ESP32-S2 Series SoC Errata (PDF)
- ESP32-S2-MINI-2 & ESP32-S2-MINI-2U Module Datasheet (PDF)
- ESP32-S2-MINI-1 & ESP32-S2-MINI-1U Module Datasheet (PDF)
- ESP32-S2-DevKitM-1 Schematics (PDF)
- ESP32-S2-DevKitM-1 PCB Layout (PDF)
- ESP32-S2-DevKitM-1 Dimensions (PDF)
- ESP Product Selector

For other design documentation for the board, please contact us at sales@espressif.com.

# Chapter 3

# ESP32-S2-HMI-DevKit-1

ESP32-S2-HMI-DevKit-1 has been specifically designed for human-machine interfaces in smart-home automation controllers, smart speakers with display, smart alarm clocks, etc.

Application examples for this board can be found at Examples .

## 3.1 ESP32-S2-HMI-DevKit-1 V1.0

This user guide will help you get started with ESP32-S2-HMI-DevKit-1 and will also provide more in-depth information.

ESP32-S2-HMI-DevKit-1 has been specifically designed for human-machine interfaces in smart-home automation controllers, smart speakers with display, smart alarm clocks, etc. This development kit supports rapid secondary development, since developers can take advantage of the kit's various onboard resources and expansion interfaces, in order to develop various functions.

The main features of the board are listed below:

- **Module Embedded:** ESP32-S2-WROVER module with 4 MB flash and 2 MB PSRAM
- **Display:** 4.3-inch TFT-LCD which uses 16-bit 8080 parallel port with 480×800 resolution and 256-level hardware DC backlight adjustment circuit, connected to an I2C capacitive touch panel
- **Audio:** Audio amplifier, built-in microphone, speaker connector
- **Storage:** microSD card connector
- **Sensors:** 3-axis accelerometer, 3-axis gyroscope, ambient light sensor, temperature and humidity sensors
- **Expansion:** SPI header, TWAI interface (compatible with CAN 2.0), I2C ADC, UART/Prog header
- **LEDs:** Programmable RGB LED and IR LED
- **Buttons:** Wake Up and Reset buttons
- **USB:** 1 x USB-C OTG (DFU/CDC) port, 1 x USB-C debug port
- **Power Supply:** 5V and 3.3V power headers
- **Optional Rechargeable Battery:** 1,950 mAh single-core lithium battery with a charge IC

The document consists of the following major sections:

- *Getting started*: Overview of the board and hardware/software setup instructions to get started.
- *Hardware Reference*: More detailed information about the board's hardware.
- *Related Documents*: Links to related documentation.

Fig. 1: ESP32-S2-HMI-DevKit-1 with ESP32-S2-WROVER module

### 3.1.1 Getting Started

This section provides a brief introduction of ESP32-S2-HMI-DevKit-1, instructions on how to do the initial hardware setup and how to flash firmware onto it.

#### Description of Components

ESP32-S2-HMI-DevKit-1 is an HMI development board designed based on the ESP32-S2. The following figure describes its key on-board resources:

The key components of the board are described in a clockwise direction.

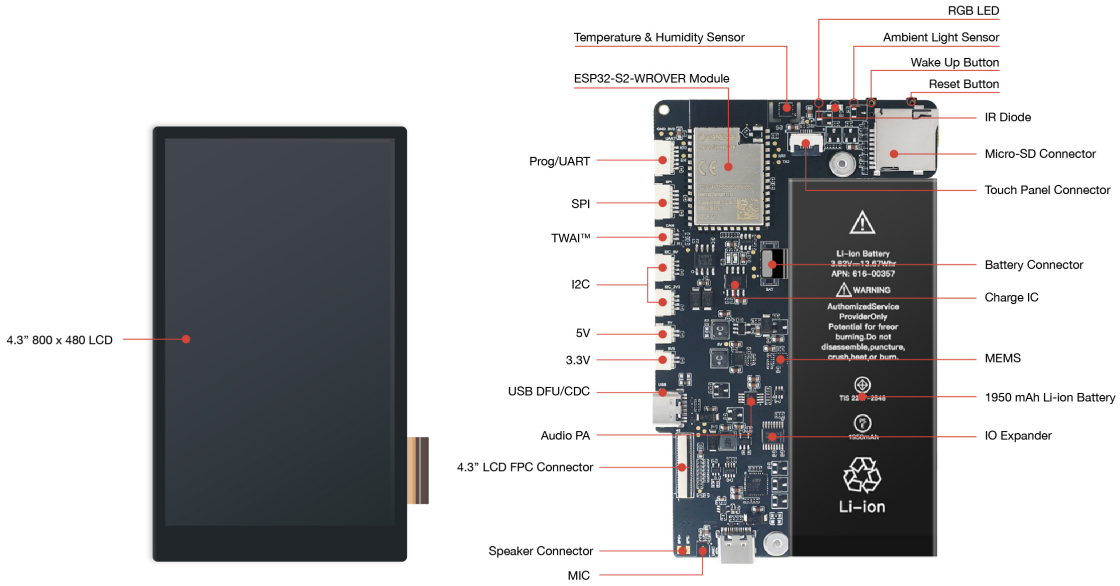



Fig. 2: ESP32-S2-HMI-DevKit-1 (click to enlarge)

| Key Component | Description |
|---|---|
| ESP32-S2-WROVER Module | ESP32-S2-WROVER is a powerful, generic Wi-Fi MCU module that integrates ESP32-S2. It has a PCB antenna, a 4 MB external SPI flash and an additional 2 MB PSRAM. |
| Temperature & Humidity Sensor | Temperature & humidity sensors for detecting ambient temperature and humidity. Read via the I2C bus. |
| RGB LED | Addressable RGB LED (WS2812), driven by GPIO21. Can switch between the LED and IR LED via IO expander. |
| Ambient Light Sensor | Ambient Light Sensor used to detect ambient light intensity. Read via the I2C bus. |
| Wake Up Button | Download button. Press and hold the **Boot** button while pressing the **Reset** button to initiate the "firmware download" mode to download the firmware via the serial port. This button can also be configured to wake up the device from deep sleep mode. |
| Reset Button | Press this button to restart the system. |
| IR LED | Infrared emitting diode, driven by GPIO21. Can switch between RGB LED and IR LED via IO expander. |
| Charge IC | Charge battery. |
| MEMS | 3-axis accelerometer and 3-axis gyroscope. |
| 1950 mAh Li-ion Battery | An optional 1,950 mAh rechargeable lithium battery. |
| IO Expander | Expand GPIO through I2C bus. |
| MIC | On-board simulated microphone. |
| Audio PA | Audio amplifier. |
| 4.3" 800 × 480 LCD | A 4.3-inch TFT-LCD which uses 16-bit 8080 parallel port with 480×800 resolution, and 256-level hardware DC backlight adjustment circuit. It is connected with an I2C capacitive touch panel overlay. |

### Start Application Development

Before powering up your board, please make sure that it is in good condition with no obvious signs of damage.

### Required Hardware

- 1 x PC loaded with Windows, macOS or Linux (Linux operating system is recommended)
- 1 x ESP32-S2-HMI-DevKit-1
- 1 x USB-C cable (it is recommended to prepare two USB-C cables if you want to evaluate MCU' s USB functions)
- 1 x Speaker (8 Ohm, 2 W)
- 1 x microSD card (some examples may have large storage needs)

---

**Note:** Be sure to use an appropriate USB cable. Some cables are for charging only and do not provide the needed data lines nor work for programming the boards.

---

**Hardware Setup** To facilitate your quick evaluation of all examples, please follow these steps to set up the board:

1. Insert microSD card into the connector. Please make sure all the important data is backed up, as the microSD card may be formatted if its partition format is not FAT.
2. If you need to evaluate the audio playback function, please connect the speaker pad near the USB port on the bottom of the board to the supplied speaker, or to another speaker with a similar size (8 Ohm, 2 W).

**Software Setup** First, please make sure you have configured the ESP-IDF development environment correctly. To ensure this, please enter `idf.py --version` in your terminal and if the output is similar to `ESP-IDF v4.2-dev-2084-g98d5b5dfd`, it means you have installed ESP-IDF correctly. For detailed information about installation and configuration, please refer to ESP-IDF Get Started.

After configuration completed, you can switch back to the `esp-dev-kits/esp32-s2-hmi-devkit-1` directory. All code examples are placed under the examples directory, you can build projects by running `idf.py build`.

**Project Options** Various examples are provided for ESP32-S2-HMI-DevKit-1 as shown below:

- Printing "Hello world!" on screen: examples/esp32-s2-hmi-devkit-1/examples/get-started/hello_world
- Blinking WS2812 LED and showing the color on screen: examples/esp32-s2-hmi-devkit-1/examples/get-started/led_blink
- Starting a UI to configure Wi-Fi credential: examples/esp32-s2-hmi-devkit-1/examples/get-started/provision
- Acquiring audio with ADC from the output of analog MIC: examples/esp32-s2-hmi-devkit-1/examples/audio/audio_record
- Playing music: examples/esp32-s2-hmi-devkit-1/examples/audio/music_player
- Shutting down selected board area into a deep sleep: examples/esp32-s2-hmi-devkit-1/examples/power
- Using Freetype to render fonts: examples/esp32-s2-hmi-devkit-1/examples/freetype
- Using on-board sensors: examples/esp32-s2-hmi-devkit-1/examples/sensors
- Using smart panel: examples/esp32-s2-hmi-devkit-1/examples/smart-panel
- Viewing files on SD card: examples/esp32-s2-hmi-devkit-1/examples/storage/sdcard_fatfs
- USB flash disk: examples/esp32-s2-hmi-devkit-1/examples/storage/usb_msc

You can configure project options by entering `idf.py menuconfig` in each example directory.

Please make sure to correctly configure the following options in menuconfig:

- `(Top) > HMI Board Config > HMI board`: Select board version. By default, please select `ESP32-S2-HMI-DevKit-V2`;
- `(Top) > HMI Board Config > Audio HAL`: Select audio output interface, whether to use PWM or DAC;
- `(Top) > HMI Board Config > LCD Drivers`: Select display IC type for LCD. By default, ESP32-S2-HMI-DevKit-1 uses RM68120 as its display IC;
- In `(Top) > Component config > ESP32S2-specific`, please go to the `Support for external, SPI-connected RAM` option:
  - Go to `SPI RAM config > Set RAM clock speed`, and set the PSRAM clock as `80 MHz clock speed`;

- `(Top) -> Component config -> FreeRTOS`: set `Tick rate (Hz)` as 1000.

In each example folder, we have provided a default configuration file named `sdkconfig.defaults`, with above options configured correctly.

**ESP-IDF Version Dependencies** The `examples/esp32-s2-hmi-devkit-1/examples/storage/usb_msc` example needs to be built in IDF v4.3, while other examples can be built in IDF v4.2 and later versions.

**Notice:** Due to strict regulation on battery export, for deliveries outside of China mainland, we are shipping ESP32-S2-HMI-DevKit-1 without the battery. As a substitute, you can use the iPhone 5 replacement battery (the connector type is non-standard). The battery capacity is not critical.

### Contents and Packaging

**Retail Orders** If you order one or several samples of the kit, each ESP32-S2-HMI-DevKit-1 development kit comes in an individual package.


Fig. 3: ESP32-S2-HMI-DevKit-1 package

The contents are as follows:

- Development board - ESP32-S2-HMI-Devit-1
- Cables - SH1.25 to 2.54mm cables x 7

For retail orders, please go to https://www.espressif.com/en/company/contact/buy-a-sample.

**Wholesale Orders** If you order in bulk, the boards come in large cardboard boxes.

For wholesale orders, please go to https://www.espressif.com/en/contact-us/sales-questions.

### 3.1.2 Hardware Reference

#### Block Diagram

The block diagram below shows the components of ESP32-S2-HMI-DevKit-1 and their interconnections.

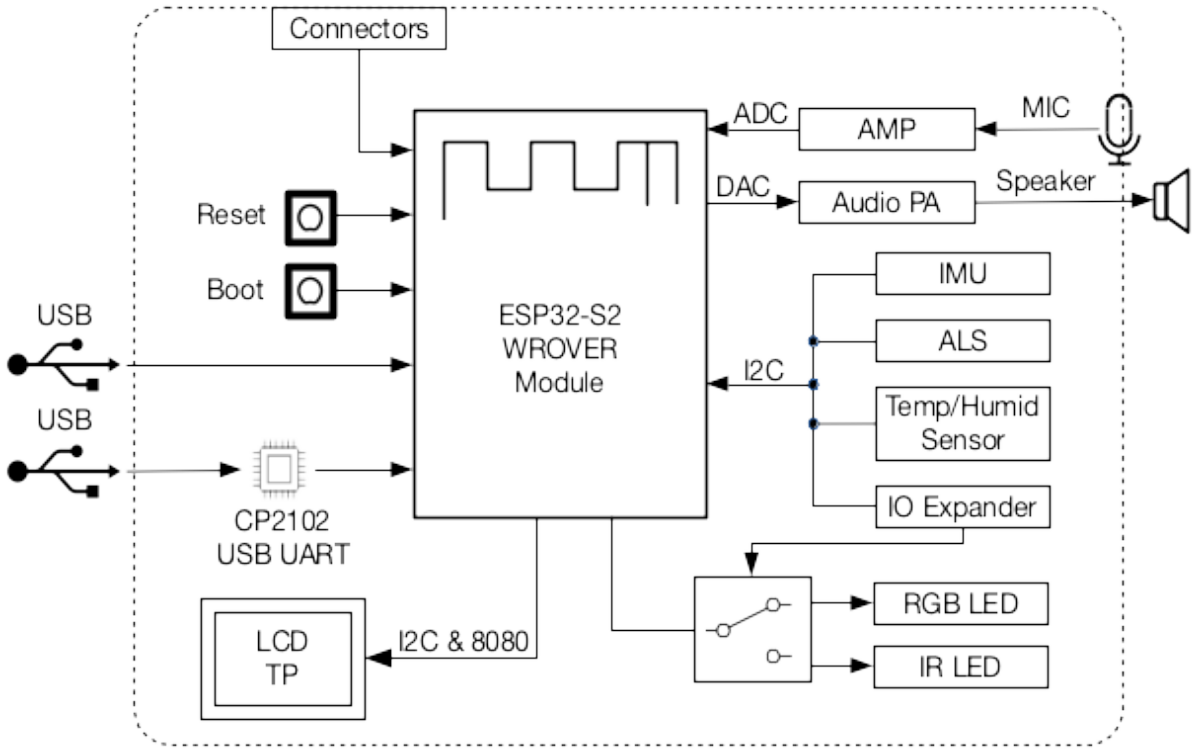



Fig. 4: ESP32-S2-HMI-DevKit-1 block diagram

#### Power Supply Options

The power of the ESP32-S2-HMI-DevKit-1 development board is divided into a 5 V power domain and a 3.3 V power domain, so as to reduce power consumption, improve power efficiency and support battery charging, part of which can be controlled by software whereas the other part is fixed in the hardware design.

To reduce current consumption, the preloaded firmware will power off all controlled power domains and put all ICs in low-power mode.

For more information, please refer to *Power*.

#### Connectors

It provides multiple extended interfaces for customized development. The connectors of the board are described in a clockwise direction. Please refer to *ESP32-S2-HMI-DevKit-1 key on-board resources*.

| Connectors | Description |
|---|---|
| Speaker Connector | To connect a speaker. |
| 4.3” LCD FPC Connector | (Reserved) Connect to the supported 4.3” LCD extension board using the FPC cable. |
| USB DFU/CDC | 1 x USB-C OTG (DFU/CDC) port, 1 x USB-C debug port. |
| 3.3 V Connector | 3.3 V power header. |
| 5 V Connector | 5 V power header. |
| I2C Connector | I2C connector with 5 V/3.3 V power supply options. |
| TWAI interface (compatible with CAN 2.0) | Two-wire automotive interface. |
| SPI | Can connect devices on the SPI bus if the SD card is not in use. |
| Prog/UART | This interface is used to observe log output and firmware flash. |
| microSD Connector | Insert microSD card to expand the storage space of the device. |
| Battery Connector | To connect a battery. |

Below is the back view of the board for your reference.


Fig. 5: ESP32-S2-HMI-DevKit-1 - back view

### 3.1.3 Related Documents

- ESP32-S2 Datasheet (PDF)
- ESP32-S2-WROVER Datasheet (PDF)
- ESP32-S2-HMI-DevKit-1 Schematic (PDF)
- ESP32-S2-HMI-DevKit-1 PCB Layout (PDF)
- ESP32-S2-HMI-DevKit-1 Dimensions (PDF)
- ESP32-S2-HMI-DevKit-1 Dimensions Source File (DXF) - You can view it with Autodesk Viewer online

For further design documentation for the board, please contact us at sales@espressif.com.

## 3.2 Reference Documentation

### 3.2.1 Audio

The ESP32-S2-HMI-DevKit-1 development board supports audio playback and recording. You can find such examples under the `examples/esp32-s2-hmi-devkit-1/examples/audio/` directory.

#### Audio Playback

The ESP32-S2-HMI-DevKit-1 development board can output audio via DAC or PWM. It is recommended to use PWM for audio output since it has lower noise and higher resolution (DAC has 8-bit resolution, while PWM can reach up to 12-bit resolution at 19.2 kHz of sampling rate).

The output signal generated through the IO port goes to the digital potentiometer TPL0401 first for lossless volume adjustment, and then passes the 100 nF isolation capacitor C33 and the 200 kOhm resistor R52. This RC circuit controls the cut-off frequency at around 8 Hz. On top of that, this signal will be sent to the 3 W class-D audio power amplifier NS4150 to set the gain to 1.5 times, thus amplifying the maximum output signal from 3.3 V to 4.95 V (slightly lower than the PA supply, 5 V) so as to maximize the output volume while minimizing saturation distortion.

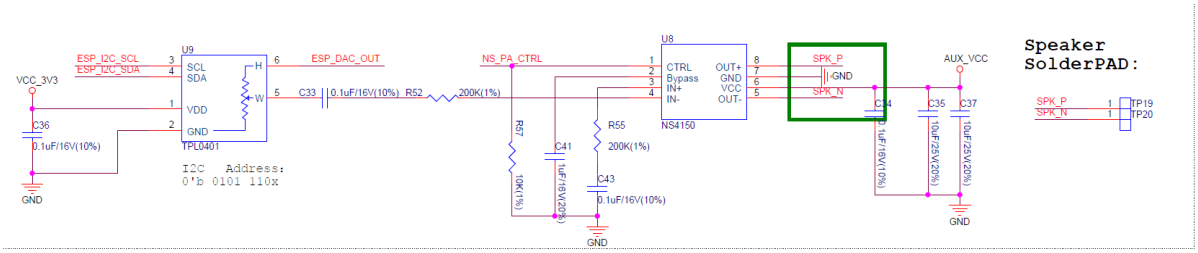



Fig. 6: ESP32-S2-HMI-DevKit-1 audio playback schematic (click to enlarge)

The audio PA is powered by the 5 V power domain. Before using the audio playback function, please make sure this power domain is powered on (refer to *5 V Power Domain* section).

#### Audio Recording

The ESP32-S2-HMI-DevKit-1 development board can record audio data from the analog microphone via an internal ADC.

The board is equipped with an analog microphone with a sensitivity of -38 dB. And it will send the output signal to the operational amplifier TLV6741 with a fixed gain to amplify the signal.

The microphone and operational amplifier mentioned above are powered by a controlled 3.3 V power domain. Before using the audio recording function, please make sure this power domain is powered on (refer to *3.3 V Power Domain* section).

Please use the Timer Group interrupt to record audio data. Do not use code such as the following format in tasks for audio recording:

```
size_t index = 0;
uint16_t audio_data[configMAX_ACQUIRE_COUNT];
do {
    audio_data[index] = adc1_get_raw(CONFIG_AUDIO_CHANNEL);
    ets_delay_us(1000000 / CONFIG_AUDIO_FREQ);
} while (++index < CONFIG_MAX_ACQUIRE_COUNT)
```

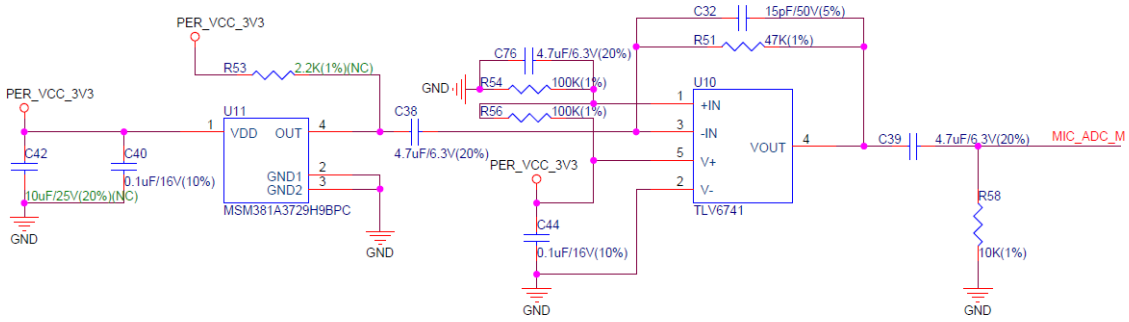



Fig. 7: ESP32-S2-HMI-DevKit-1 microphone schematic (Click to enlarge)

The above format will cause the CPU to be occupied, thus triggering the task watchdog (if it is not disabled), and make other tasks with lower priorities (e.g., IDLE Task) not able to operate normally.

When recording data via ADC with the interrupt function, you need to re-write the ADC recording function to `IRAM_ATTR` so as to reduce response time, and place the variables to DRAM. Also, please do not use any semaphore in this function. For more information about implementation examples, please refer to `audio/audio_record` under the `examples` directory.

#### ADC Accuracy

The ADC of ESP32-S2 has a high level of repeatability despite the fact that the lack of reference voltage and using Buck power supply may result a high overall noise.

The ADC is configured with 13-bit resolution and 11 dB attenuation, corresponding to a full-scale voltage of 2.6 V. After polling the 2.5 V voltage of the AD584T reference voltage via ADC1_CH8, we convert the 4096-time uncalibrated raw values into voltage values and get the following data:

As shown in the above figure, most of the uncalibrated data error is within the range of ±0.005 V with a standard deviation (σ) of 3.339 LSB (0.00106 V). These errors are mainly from the absolute accuracy, i.e., the bias. Therefore, the distortion and noise of sounds sampled via ADC can be kept at a relatively low level.

The AD584T has a peak output noise of 50 uV at 10 V within the range of 0.1 ~ 10 Hz, and a peak output noise divided by the internal high-precise laser-adjusted resistor at 2.5 V. And an up to 30 mA push-pull capability is provided by the transistor measured at 10 V. Its output noise at 2.5 V is lower than the resolving power of a 16-bit ADC, which therefore can be used as a testing reference.

### 3.2.2 Display and Touch Panel

The ESP32-S2-HMI-DevKit-1 has a 4.3-inch color TFT-LCD with 800×480 resolution, and a touch panel with an I2C interface. The interface type and data bit width of this display is controlled by programmable pins. This development board has been configured as 16-bit 8080 parallel communication via resistors.

This LCD uses RM68120 as its display IC and FT5436 as its touch IC.

#### Communication

The display IC of the LCD used in ESP32-S2-HMI-DevKit-1 has been configured for 16-bit 8080 parallel communication, with a total of 18 GPIOs used, i.e., 16 data lines (LCD_D0⋯LCD_D15), a bit clock signal (LCD_WR) and a data/command distinguish signal (LCD_DC/LCD_RS).

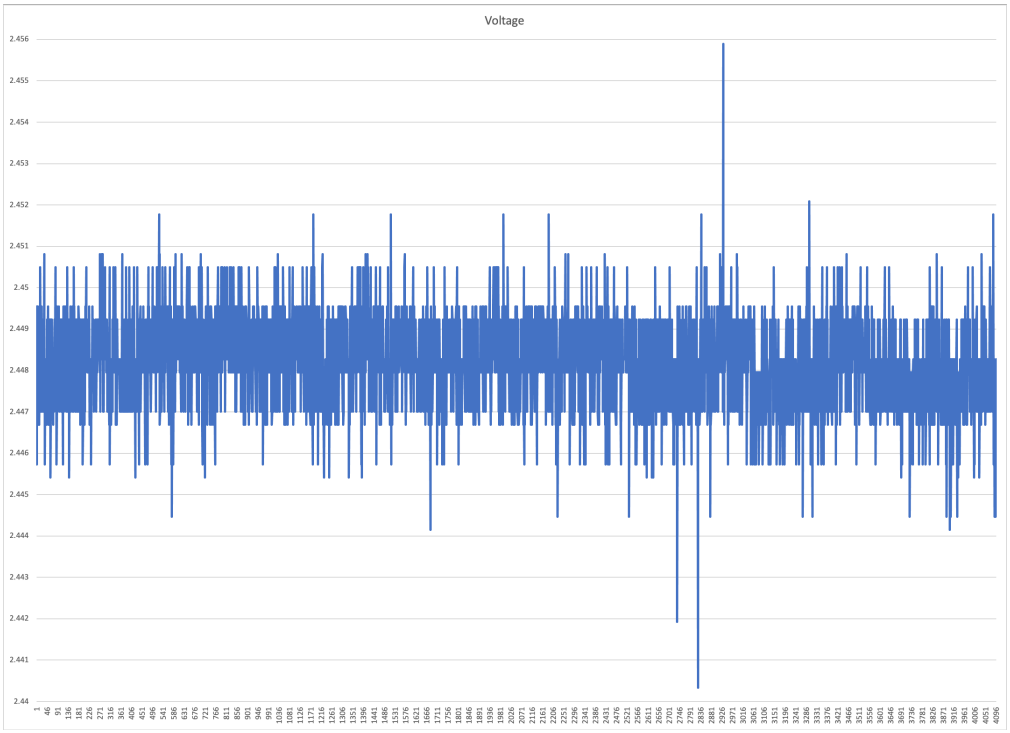



Fig. 8: ESP32-S2-HMI-DevKit-1 ADC (click to enlarge)

The touch IC uses the I2C interface to communicate with MCU and can share this interface with other I2C' s ICs, and thus does not need to use additional GPIOs. The touch IC supports interrupt signal output. The interrupt signal is first sent to the P2 pin of the IO expander, and the falling edge from this pin will generate a low level in the interrupt output pin of the IO expander, so that the MCU receives this interrupt signal. In this case, you can read the input level register of the IO expander to check whether this interrupt is from the touch IC. Once a read operation completed, the interrupt flag will be cleared.

### Backlight

As the LEDs are connected in series, they need to be drived by constant current via the Booster circuit. The rated current is 18 mA and the voltage is approximately 24 V (may not be accurate, only for reference). To prevent the feedback voltage of the Booster circuit always being 0 when the display is not connected, and thus causing high voltage loaded to both ends of the backlight filter capacitor C21, please make sure this capacitor can withstand 38 V.

Since PWM dimming may cause display flicker and some Booster IC do not support high-frequency PWM signal control, this development board provides an option to use DC dimming circuit to reach high performance, as shown in the figure below:

This DC dimming circuit inputs the VFB voltage to the operational amplifier TLV6741, whose gain resistor is a digital potentiometer that can be modified via the I2C bus. This digital potentiometer is CAT5171, with 256 levels of resolution and a maximum resistance value of 50 kOhm.

The EN pin of the Booster IC is controlled by the P7 pin of the IO expander in high level. If you want to keep the contents while turning off the display, please set this pin to low level so as to disable backlight.

### Touch

The capacitive touch panel on the development board uses a touch IC with a resolution of 800×480 and supports up to 5-point touch and hardware gesture recognition.

The hardware of this display IC does not support screen rotation itself. Therefore, for scenarios where the panel is needed to be rotated, you may need to convert the data read by the touch IC through calculating its relative value to

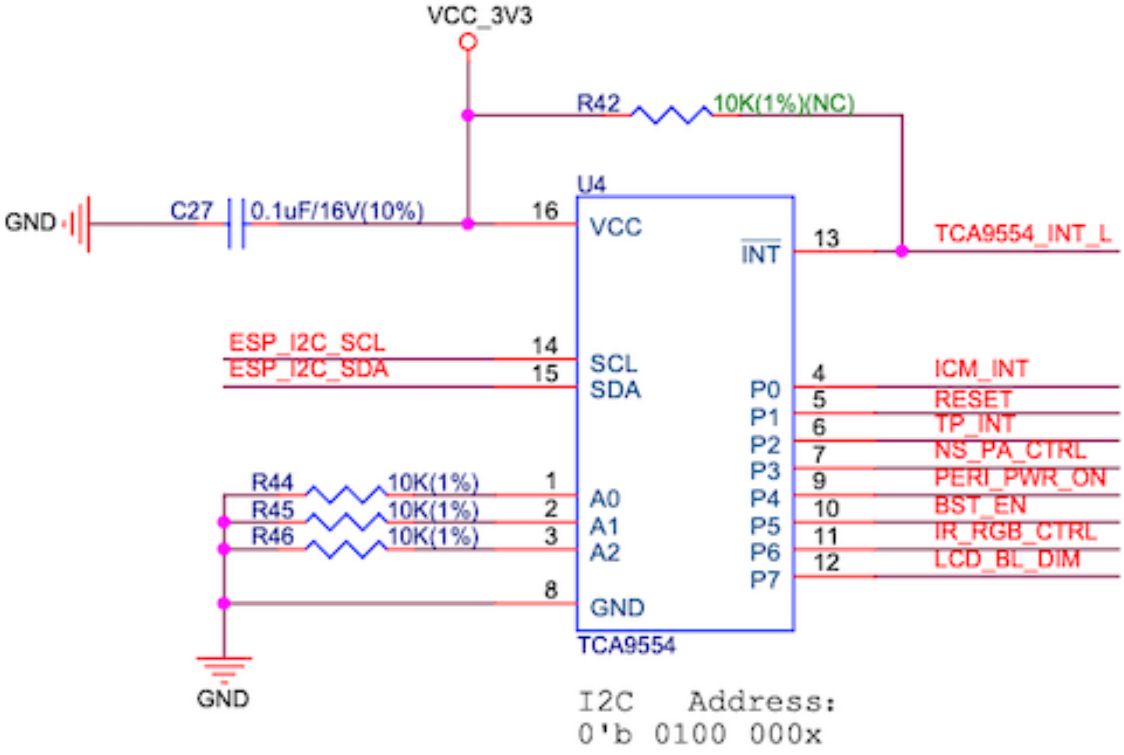



Fig. 9: ESP32-S2-HMI-DevKit-1 IO expander schematic

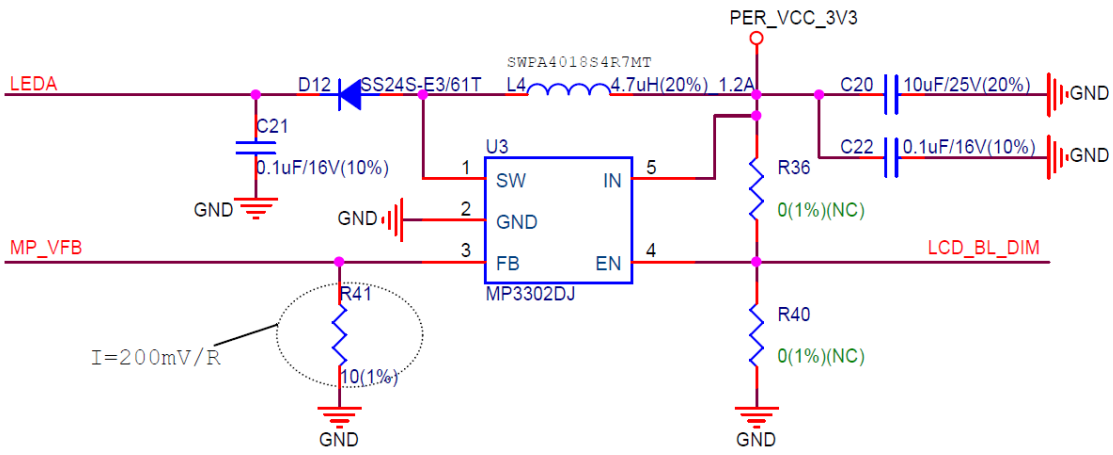



Fig. 10: ESP32-S2-HMI-DevKit-1 backlight PWM dimming schematic (click to enlarge)

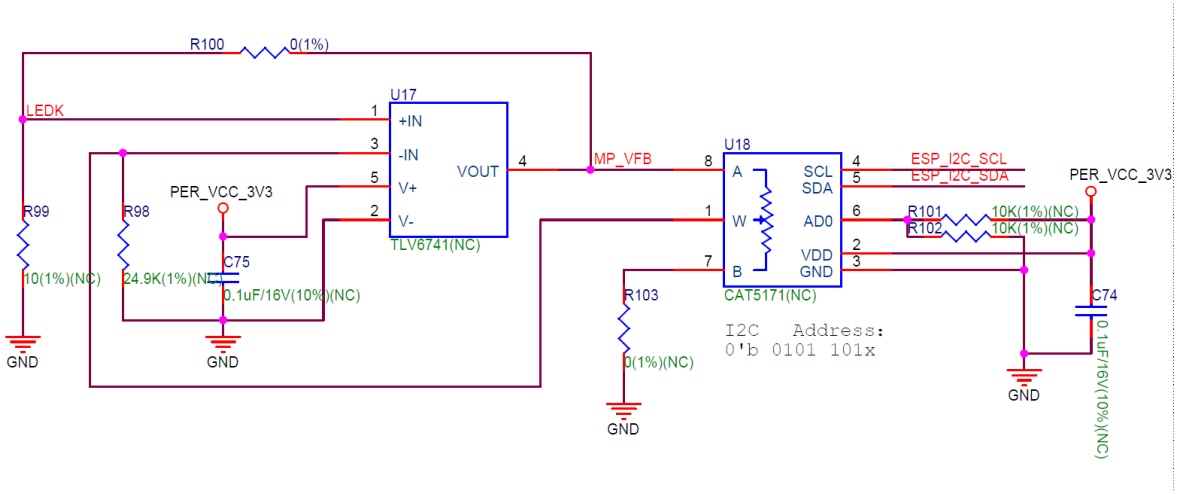



Fig. 11: ESP32-S2-HMI-DevKit-1 DC dimming circuit schematic (click to enlarge)

the resolution or via certain software. Multi-touch is supported by hardware and we provide some APIs for reading the multiple touch points. However, since the LVGL used in the GUI library does not support multi-touch processing for now, you may need to handle the data of these touch points in the application layer yourself.

### 3.2.3 Power

The power of the ESP32-S2-HMI-DevKit-1 development board is divided into a 5 V power domain and a 3.3 V power domain, so as to reduce power consumption, improve power efficiency and support battery charging. Part of the power domain can be controlled by software whereas the other part is configured as permanently enabled in hardware design.

To reduce current consumption, the preloaded firmware will power off all controlled power domains and put all ICs to low-power mode.

#### 3.3 V Power Domain

Most of the ICs and modules are powered by the 3.3 V power domain, which can be divided into an uncontrolled 3.3 V power domain and a controlled 3.3 V power domain.

The uncontrolled 3.3 V power domain cannot be powered off via software, and provides power for the Buck circuit. When there is a power supply from USB, this power domain will obtain power from the 5 V input through the USB cable; when USB is disconnected, it will obtain 3.6 ~ 4.2 V power from the lithium battery. This power domain mainly provides power for the ESP32-S2-WROVER module and other devices which can enter low-power mode via software control.

The controlled 3.3 V power domain comes from the uncontrolled 3.3 V power domain and is turned on/off via a PMOS control switch, which is connected to the P4 pin of the IO expander. This power domain mainly provides power for ICs with higher static power consumption and cannot enter low-power mode.

#### 5 V Power Domain

The 5 V power domain of the development board provides power for the audio amplifier and the TWAI® transceiver. It obtains power from the following resources:

- The USB port
- The power input from external 5 V power port
- The power passing through the Booster circuit from the lithium battery

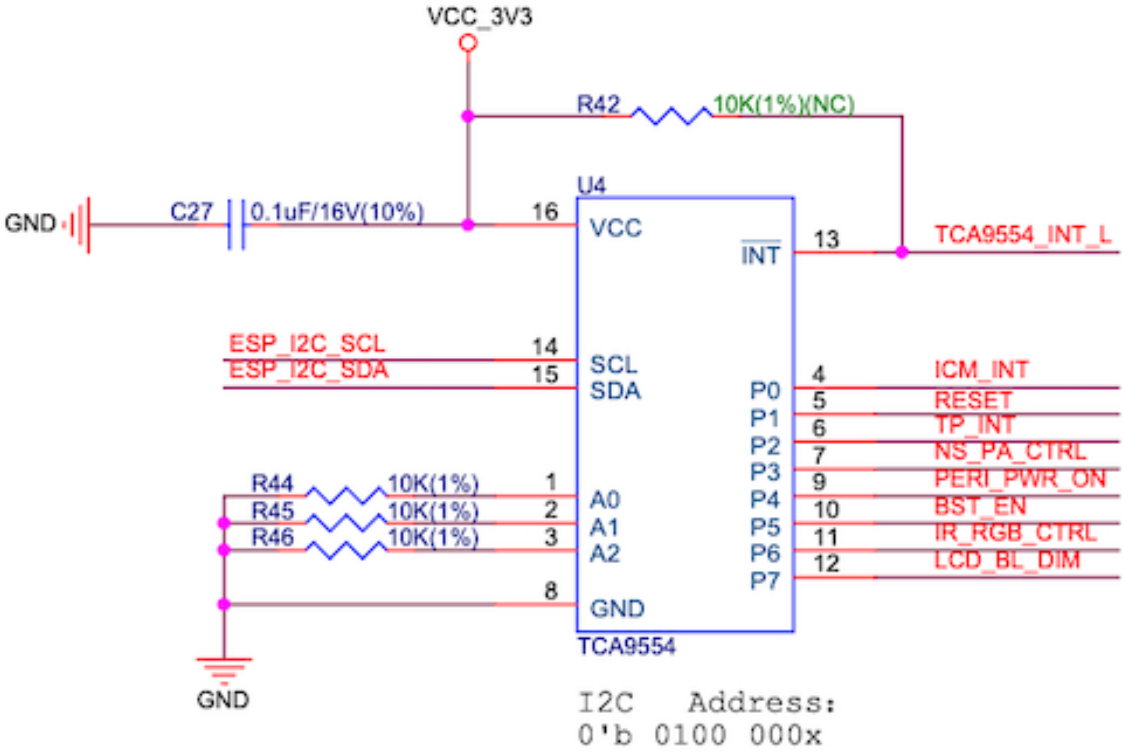



Fig. 12: ESP32-S2-HMI-DevKit-1 IO expander schematic

The power obtained from USB and the external 5 V power input supplies power for all devices (except CP2102N) that require 5 V power and cannot be disconnected by software. When obtaining power from the lithium battery, the EN pin level of the Booster IC can be controlled via the P5 pin of the IO expander to enable 5 V power in high level.

The power input through the USB port on the bottom of the board is split into two lines: one provides power for CP2102N while the other becomes USB_5V after passing through a diode. The CP2102N will only be powered up when this USB port is connected, since it only needs to be in operation when the PC is connected. Any 5 V power input will cause the Booster IC to be powered off and charge the on-board lithium battery via the charging IC.

### Power Dependencies

The following functions depend on the 5 V power domain:

- TWAI® (selects available power supply from USB 5 V or Booster 5 V automatically)
- Audio amplifier (gets power supply from USB 5 V, if it fails, will try from the battery)
- 5 V power output connector (the same as TWAI®)

The following functions depend on the controlled 3.3 V power domain:

- Micro-SD card
- Microphone and its bias circuit, and operational amplifier
- Display and touch function
- WS2812 RGB LED and IR LED
- IR LED

### Power State

When the development board is connected via the USB cable, the 5 V power domain is powered on automatically and the charging IC outputs voltage to supply power for the battery. In this case, the controlled 3.3 V power domain is controlled by the P4 pin of the IO expander.

When the development board is powered by the battery, the controlled 3.3 V power domain is controlled by the P4 pin of the IO expander while the 5 V power domain is controlled by the P5 pin of the IO expander, and the charging IC will not work.

# Chapter 4

# ESP32-S2-Touch-Devkit-1

ESP32-S2-Touch-Devkit-1 is a development kit that is aimed at helping evaluate and develop capacitive touch sensor applications on ESP32-S2. It is made up of a Motherboard-Subboard structure.

## 4.1 ESP32-S2-Touch-Devkit-1

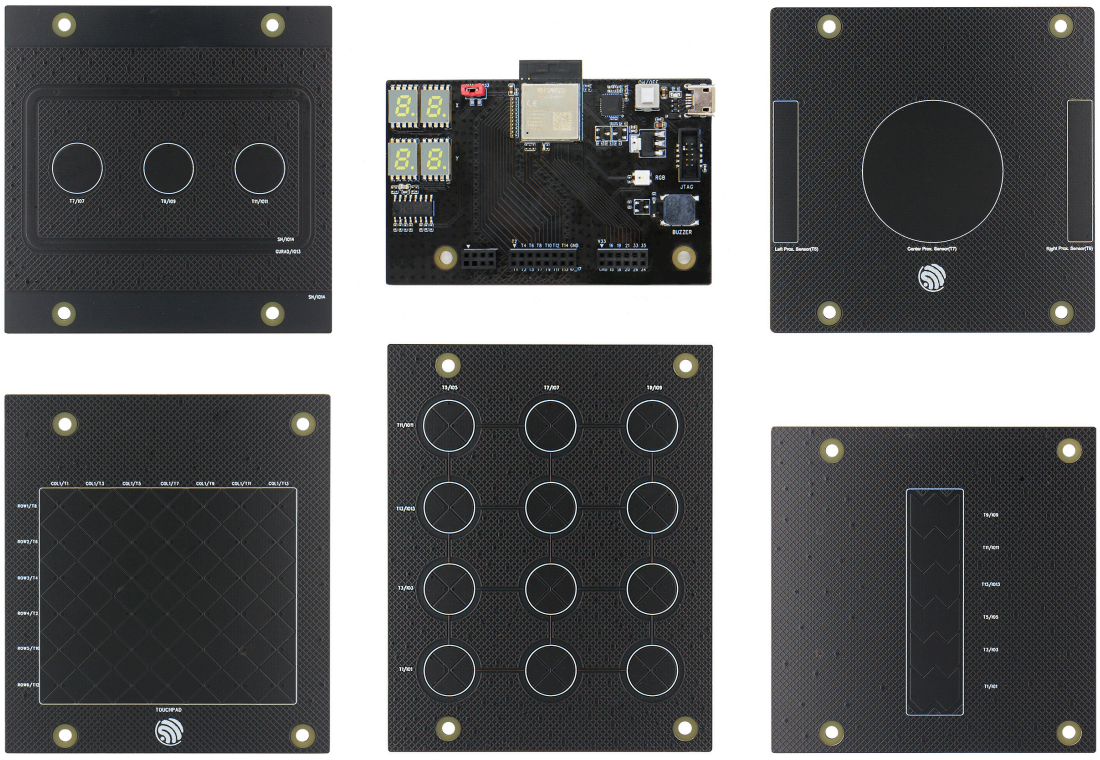


Fig. 1: ESP32-S2-Touch-Devkit-1 Board-set

### 4.1.1 Overview

ESP32-S2-Touch-Devkit-1 is a development kit that is aimed at helping evaluate and develop capacitive touch sensor applications on ESP32-S2. It is made up of Motherboard-Subboard structure. The motherboard of ESP32-S2-Touch-Devkit-1 integrates ESP32-S2-MINI-1 controller module and several useful little components such as buzzer, digital tube, RGB light, and so on. There are several kinds of subboards in ESP32-S2-Touch-Devkit-1 with different kinds of capacitive touch sensor pads, developers can choose one of them and connect it with motherboard so that they could develop different kinds of capacitive touch sensor applications. The motherboard and subboard use the pin header/female pin header as the socket connector which makes it plug in and plug out smoothly.

**Motherboard**

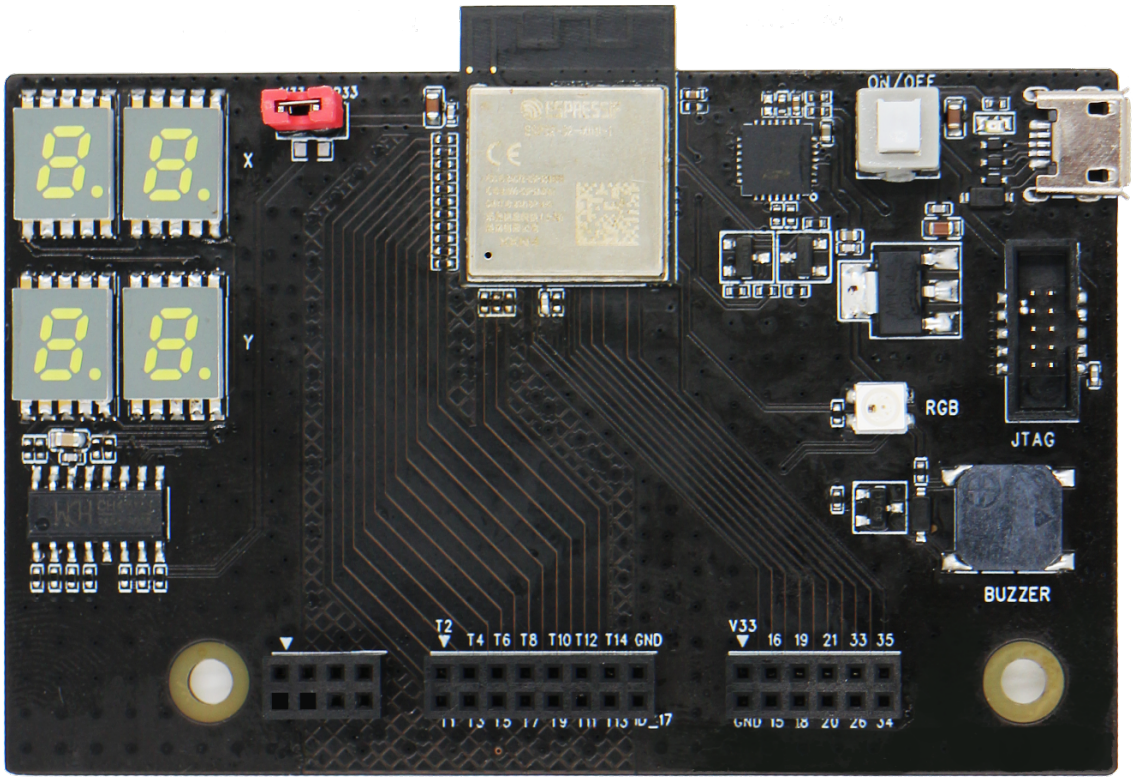
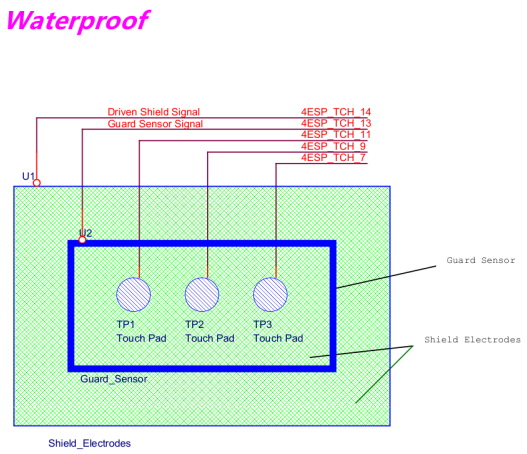



Fig. 2: Motherboard

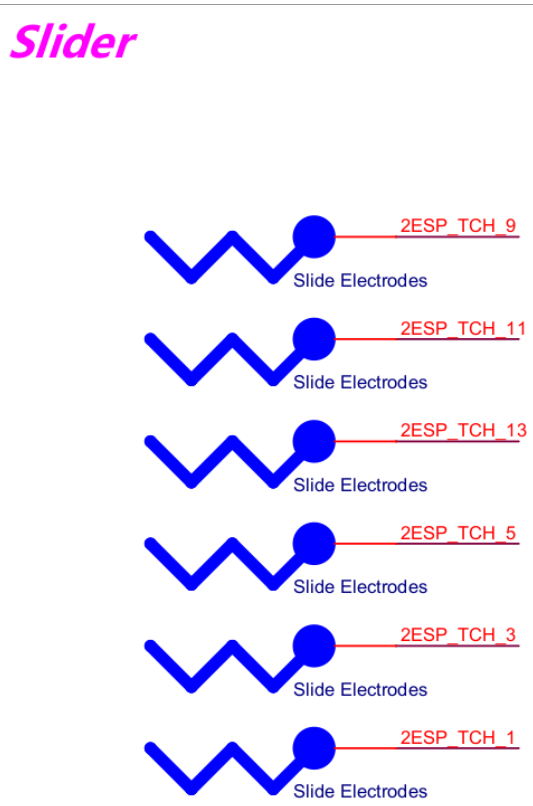
**Subboards**

- Button-board: Three capacitive touch buttons with waterproof sensor.



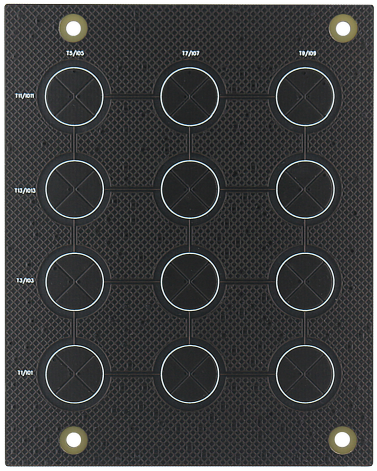

Button-board Water-proof sensor

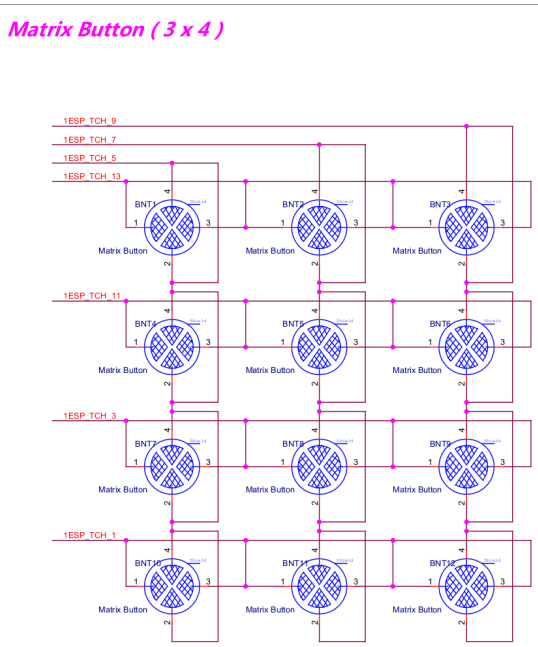
- Slider-board: Capacitive touch linear slider, the relative distance of slider has up to 8-bit precision.




Slider-board Slider

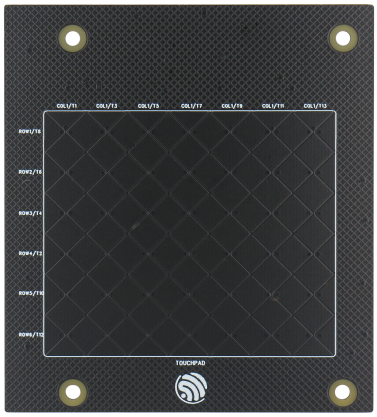
- Matrix-board: 3 x 4 capacitive touch matrix button, 7 channels of touch sensor make up of 12 capacitive touch buttons.

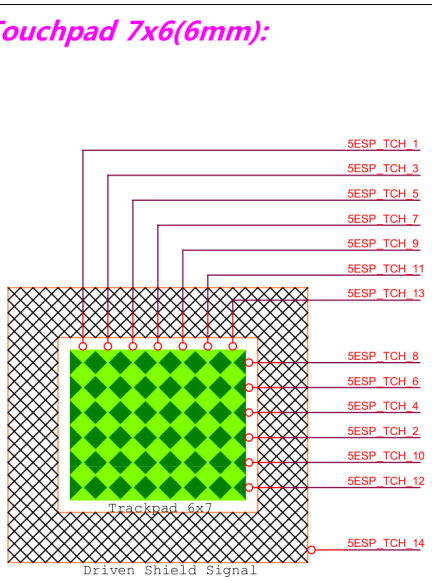





Matrix-board Matrix button

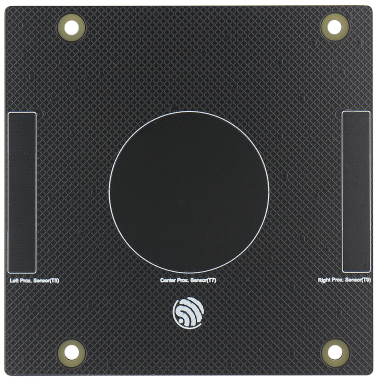
- Touchpad-board: 7 x 6 two-dimension capacitive touchpad.

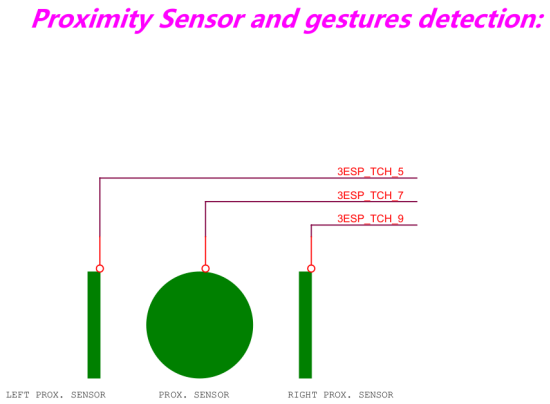





Touchpad-board Touchpad

- Proximity-board: Three capacitive touch proximity sensors.






Proximity-board Sensor

### 4.1.2 Get Started

**Install SDK and it's dependencies**:

1. Install ESP-IDF, please refer to ESP-IDF Programming Guide.
2. Use the release-4.3 version of ESP-IDF.

```
cd esp-idf #Enter esp-idf folder
git checkout release/v4.3 #Checkout release-v4.3 version of ESP-IDF
git submodule update #Maybe is needed
```

**Get ESP32-S2-Touch-Devkit-1 project**:

1. Clone esp-dev-kits repo.

```
git clone https://github.com/espressif/esp-dev-kits.git
```

2. Enter ESP32-S2-Touch-Devkit-1 project folder.

```
cd esp-dev-kits/esp32-s2-touch-devkit-1
```

The project's structure is shown as followed:

```
├── CMakeLists.txt
├── components                  #components' driver
│   ├── board_detect        #subboard detector
│   ├── buzzer                  #buzzer driver
│   ├── digital_tube        #digital tube controller driver
│   ├── rgb_light           #RGB light driver(ws2812)
│   ├── subboards           #Subboards' application source file
│   └── touch_element           #Touch element library
├── main            #Main application demo logic
│   ├── CMakeLists.txt
│   └── main.c
```

**Build & Flash ESP32-S2-Touch-Devkit-1 demo project**:

1. Enable ESP-IDF environment variable.

```
cd esp-idf
. ./export.sh
```

2. Build & Flash.

```
cd esp-dev-kits/esp32-s2-touch-devkit-1
idf.py set-target esp32s2 #Enable esp32s2 platform
idf.py build flash
```

3. Monitor log output.

```
idf.py monitor
```

Example output:

```
I (2880) Touch Demo: Slider sub-board plug in
I (22480) Touch Demo: Slider sub-board plug out
I (22480) Touch Demo: Nothing detected
I (41540) Touch Demo: Touchpad sub-board plug in
I (47700) Touchpad Board: Touchpad pressed, position: [0, 5]
I (47710) Touchpad Board: Position: [0, 5]
I (47720) Touchpad Board: Position: [0, 5]
I (47730) Touchpad Board: Position: [0, 6]
I (47740) Touchpad Board: Position: [0, 6]
I (47750) Touchpad Board: Position: [0, 6]
I (47760) Touchpad Board: Position: [0, 6]
I (47770) Touchpad Board: Position: [0, 7]
I (47780) Touchpad Board: Position: [0, 8]
I (47790) Touchpad Board: Position: [0, 9]
I (47800) Touchpad Board: Position: [0, 9]
I (47810) Touchpad Board: Position: [1, 10]
I (47820) Touchpad Board: Position: [2, 11]
I (47830) Touchpad Board: Position: [2, 12]
I (47840) Touchpad Board: Position: [3, 13]
I (47850) Touchpad Board: Position: [4, 14]
I (47860) Touchpad Board: Position: [5, 15]
I (47870) Touchpad Board: Position: [6, 16]
I (47880) Touchpad Board: Position: [7, 16]
I (47890) Touchpad Board: Position: [9, 17]
I (47900) Touchpad Board: Position: [10, 18]
I (47910) Touchpad Board: Position: [11, 18]
I (47920) Touchpad Board: Position: [11, 19]
I (47930) Touchpad Board: Position: [12, 20]
I (47940) Touchpad Board: Position: [13, 21]
I (47950) Touchpad Board: Position: [14, 21]
I (47960) Touchpad Board: Position: [14, 22]
I (47970) Touchpad Board: Position: [15, 23]
I (47980) Touchpad Board: Position: [15, 23]
I (47990) Touchpad Board: Position: [15, 24]
I (48000) Touchpad Board: Position: [15, 24]
I (48010) Touchpad Board: Position: [15, 24]
I (48020) Touchpad Board: Position: [16, 24]
I (48030) Touchpad Board: Position: [16, 24]
I (48040) Touchpad Board: Position: [16, 24]
I (48050) Touchpad Board: Position: [16, 23]
I (48060) Touchpad Board: Position: [16, 23]
I (48070) Touchpad Board: Position: [16, 22]
I (48080) Touchpad Board: Position: [16, 22]
I (48090) Touchpad Board: Position: [16, 21]
I (48100) Touchpad Board: Touchpad released, position: [16, 21]
```

### 4.1.3 Notes

- Some new Touch Sensor features (Touchpad, Touch proximity) are not supported in ESP-IDF Touch Element library, so we copy Touch Element from ESP-IDF components into this demo project's components' folder and add the necessary features. They will appear in the future version of ESP-IDF.

### 4.1.4 Troubleshooting

Q1: Why Proximity-board is connected with Motherboard, they don’ t work or work abnormally?

A1: Though all of those subboards are hot-swappable theoretically, the Proximity-board needs to startup in an ideal environment(Far away from your hands). If it goes wrong, you can reset it mandatorily by releasing the power-switch.

### 4.1.5 Related Documents

#### Schematic

- ESP32-S2-Touch-Devkit-1 Motherboard Schematic
- Button Subboard Schematic
- Slider Subboard Schematic
- Matrix Button Subboard Schematic
- Touchpad Subboard Schematic
- Proximity Subboard Schematic

#### Other Documents

- Touch Element Library Programming Guide
- ESP32-S2-MINI-1 Datasheet
- ESP32-S2 Datasheet
- ESP32-S2 Technical Reference Manual

# Chapter 5

# ESP32-S2-Kaluga-1

The ESP32-S2-Kaluga-1 kit is a development kit by Espressif.

Application examples for this kit can be found at Examples .

## 5.1 ESP32-S2-Kaluga-1 Kit v1.3

Older version: *ESP32-S2-Kaluga-1 Kit v1.2*

The ESP32-S2-Kaluga-1 kit v1.3 is a development kit by Espressif that is mainly created to:

- Demonstrate the ESP32-S2' s human-computer interaction functionalities
- Provide the users with the tools for development of human-computer interaction applications based on the ESP32-S2

There are many ways of how the ESP32-S2' s abundant functionalities can be used. For starters, the possible use cases may include:

- **Smart home**: From simplest smart lighting, smart door locks, smart sockets, to video streaming devices, security cameras, OTT devices, and home appliances
- **Battery-powered equipment**: Wi-Fi mesh sensor networks, Wi-Fi-networked toys, wearable devices, health management equipment
- **Industrial automation equipment**: Wireless control and robot technology, intelligent lighting, HVAC control equipment, etc.
- **Retail and catering industry**: POS machines and service robots

The ESP32-S2-Kaluga-1 kit consists of the following boards:

- Main board: *ESP32-S2-Kaluga-1*
- Extension boards:
  - *ESP-LyraT-8311A v1.3* - audio player
  - *ESP-LyraP-TouchA v1.1* - touch panel
  - *ESP-LyraP-LCD32 v1.2* - 3.2" LCD screen
  - *ESP-LyraP-CAM v1.1* - camera board

Due to the presence of multiplexed pins on ESP32-S2, certain extension board combinations have limited compatibility. For more details, please see *Compatibility of Extension Boards*.

This document is **mostly dedicated to the main board** and its interaction with the extension boards. For more detailed information on each extension board, click their respective links.

This guide covers:

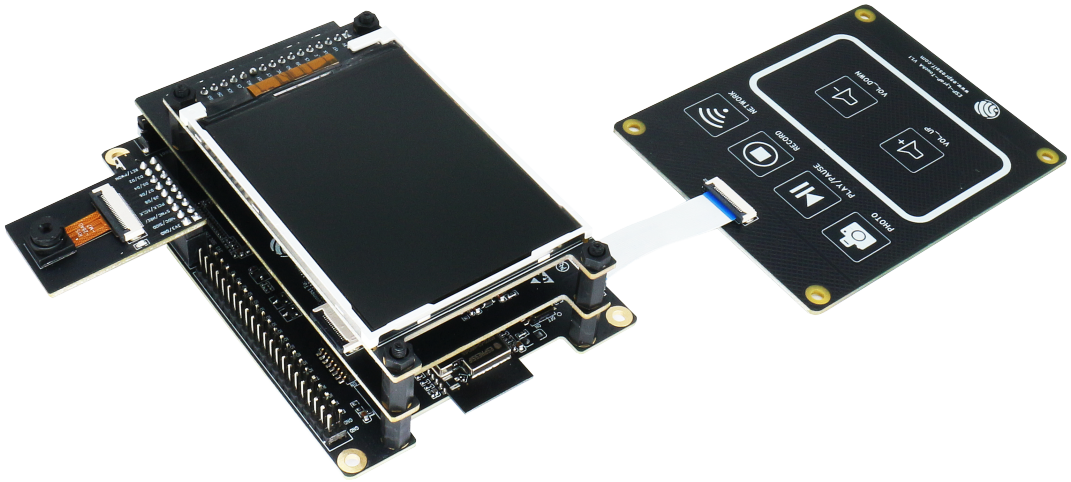


Fig. 1: ESP32-S2-Kaluga-1-Kit Overview (click to enlarge)

- *Getting Started*: Provides an overview of the ESP32-S2-Kaluga-1 and hardware/software setup instructions to get started.
- *Hardware reference*: Provides more detailed information about the ESP32-S2-Kaluga-1 ' s hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP32-S2-Kaluga-1.
- *Related Documents*: Gives links to related documentation.

### 5.1.1 Getting Started

This section describes how to get started with the ESP32-S2-Kaluga-1. It begins with a few introductory sections about the ESP32-S2-Kaluga-1, then Section *Start Application Development* provides instructions on how to do the initial hardware setup and then how to flash firmware onto the ESP32-S2-Kaluga-1.

#### Overview

The ESP32-S2-Kaluga-1 main board is the heart of the kit. It integrates the ESP32-S2-WROVER module and all the connectors for extension boards. This board is the key tool in prototyping human-computer interaction interfaces.

The ESP32-S2-Kaluga-1 board has connectors for boards with:

- Extension header (ESP-LyraT-8311A, ESP-LyraP-LCD32)
- Camera header (ESP-LyraP-CAM)
- Touch FPC connector (ESP-LyraP-TouchA)
- LCD FPC connector (no official extension boards yet)
- I2C FPC connector (no official extension boards yet)

All the four extension boards are specially designed to support the following features:

- **Touch panel control**
  - Six touch buttons
  - Supports acrylic panels up to 5 mm
  - Wet hand operation
  - Water rejection, ESP32-S2 can be configured to disable all touchpads automatically if multiple pads are simultaneously covered with water and to re-enable touchpads if the water is removed
- **Audio playback**
  - Connect speakers to play audio
  - Use together with the Touch panel to control audio playback and adjust volume

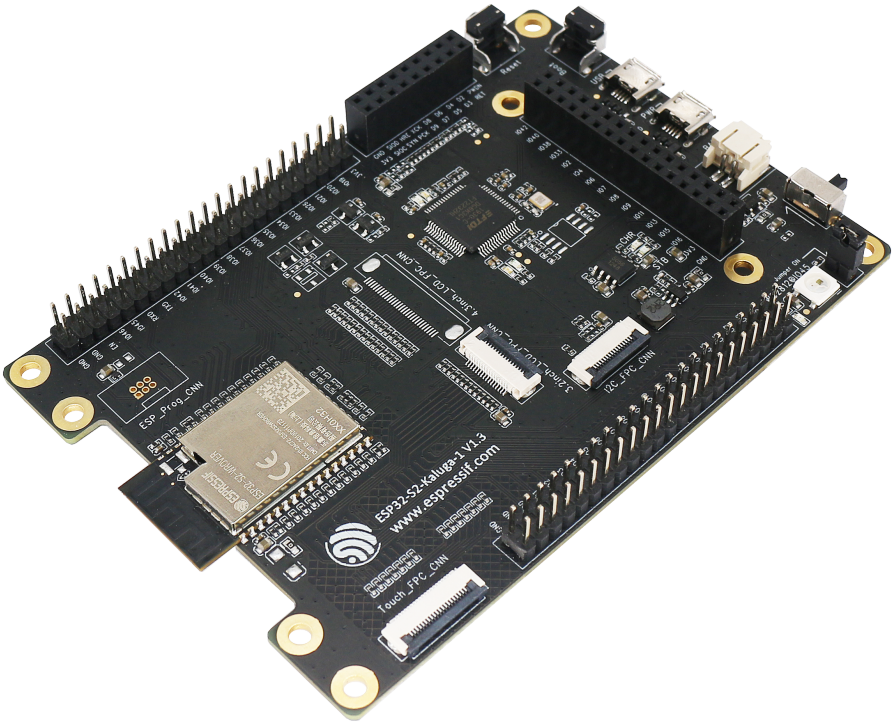



Fig. 2: ESP32-S2-Kaluga-1 (click to enlarge)

- **LCD display**
  - LCD interface (8-bit parallel RGB, 8080, and 6800 interface)
- **Camera image acquisition**
  - Supports OV2640 and OV3660 camera modules
  - 8-bit DVP image sensor interface (ESP32-S2 also supports 16-bit DVP image sensors, you can design it yourself)
  - Clock frequency up to 40 MHz
  - Optimized DMA transmission bandwidth for easier transmission of high-resolution images

## Description of Components

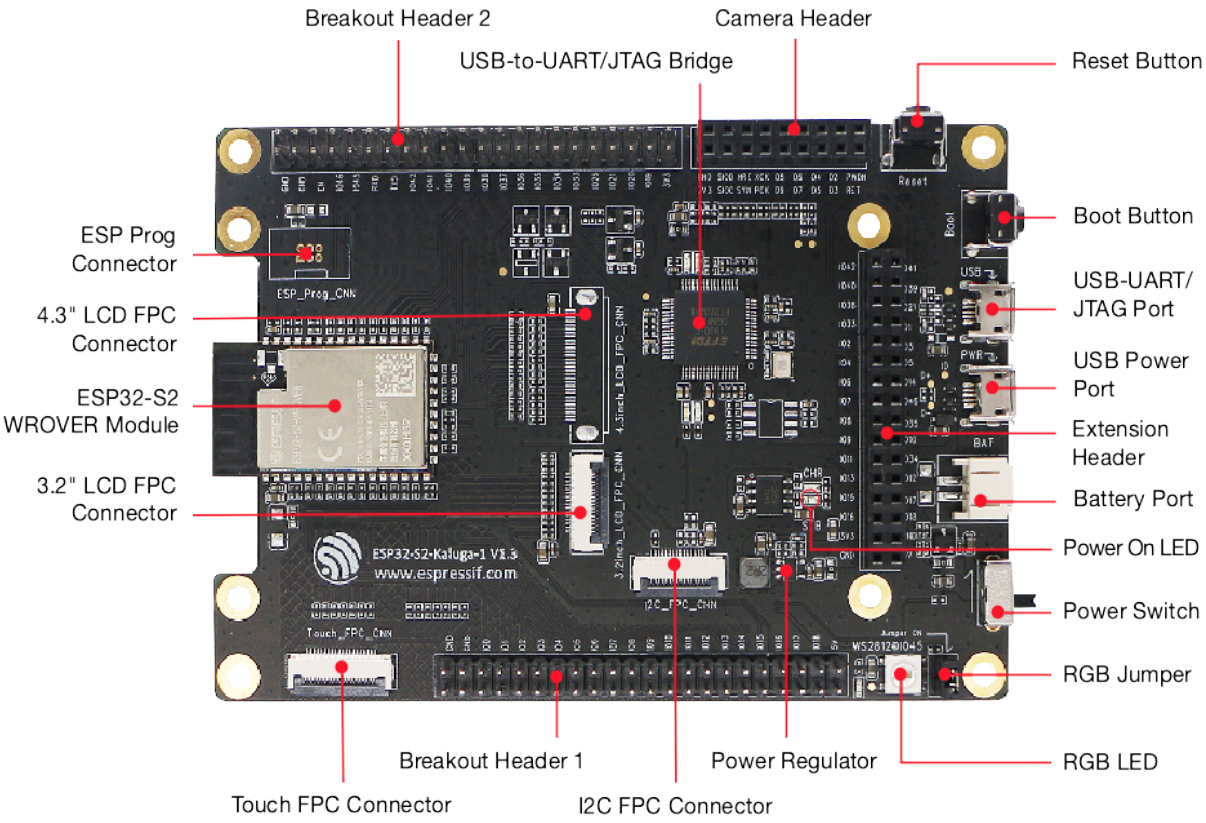



Fig. 3: ESP32-S2-Kaluga-1 - front (click to enlarge)

The description of components starts from the ESP32-S2 module on the left side and then goes clockwise.

**Reserved** means that the functionality is available, but the current version of the kit does not use it.

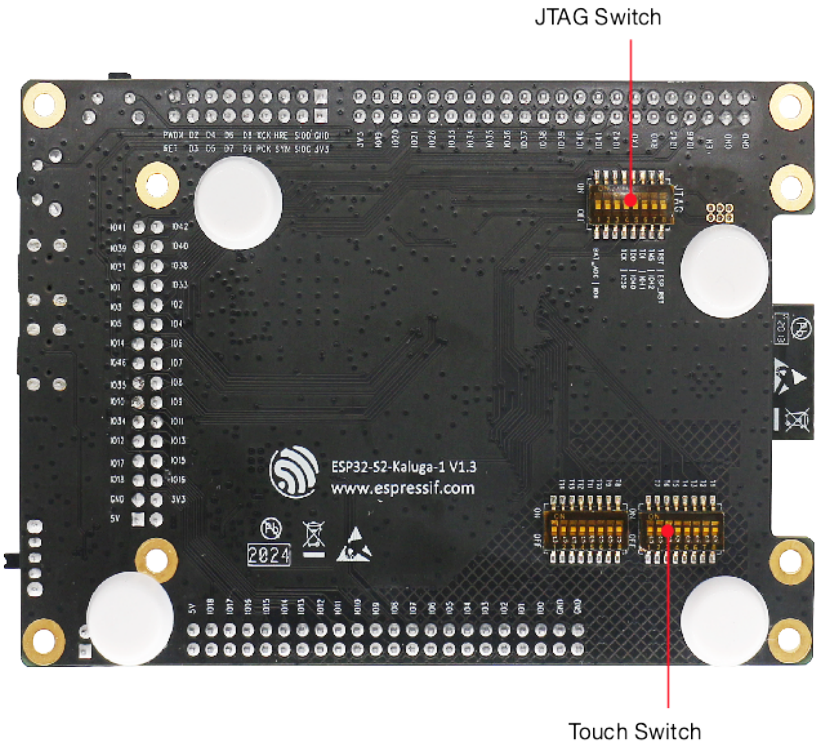



Fig. 4: ESP32-S2-Kaluga-1 - back (click to enlarge)

| Key Component | Description |
|---|---|
| ESP32-S2-WROVER Module | Module integrating the ESP32-S2 chip that provides Wi-Fi connectivity, data processing power, and flexible data storage. |
| 4.3” LCD FPC Connector | (Reserved) Connect to a 4.3” LCD extension board using the FPC cable. |
| ESP Prog Connector | (Reserved) Connection for Espressif ’ s download device (ESP-Prog) to flash ESP32-S2 system. |
| JTAG Switch | Switch to ON to enable connection between ESP32-S2 and FT2232; JTAG debugging will then be possible using USB-UART/JTAG Port. See also JTAG Debugging. |
| Breakout Header 2 | Some GPIO pins of the ESP32-S2-WROVER module are broken out to this header, see labels on the board. |
| USB-to-UART/JTAG Bridge | FT2232 adapter board allowing for communication over USB port using UART/JTAG protocols. |
| Camera Header | Mount a camera extension board here (e.g., ESP-LyraP-CAM). |
| Extension Header | Mount the extension boards having such connectors here. |
| Reset Button | Press this button to restart the system |
| Boot Button | Holding down **Boot** and then pressing **Reset** initiates Firmware Download mode for downloading firmware through the serial port. |
| USB-UART/JTAG Port | Communication interface (UART or JTAG) between a PC and the ESP32-S2 module. |
| USB Power Port | Power supply for the board. |
| Battery Port | Connect an external battery to the 2-pin battery connector. |
| Power On LED | Turns on when the USB or an external power supply is connected to the board. |
| Power Switch | Switch to ON to power the system. |
| RGB Jumper | To have access to the RGB LED, place a jumper onto the pins. |
| RGB LED | Programmable RGB LED and controlled by GPIO45. Before using it, you need to put RGB Jumper ON. |
| Power Regulator | Regulator converts 5 V to 3.3 V. |
| I2C FPC Connector | (Reserved) Connect to other I2C extension boards using the FPC cable. |
| Breakout Header 1 | Some GPIO pins of the ESP32-S2-WROVER module are broken out to this header, see labels on the board. |
| Touch FPC Connector | Connect the ESP-LyraP-TouchA extension board using the FPC cable. |
| Touch Switch | In OFF position, GPIO1 to GPIO14 can be used for connection to touch sensors; switch to ON if you want to use them for other purposes. |
| 3.2” LCD FPC connector | Connect a 3.2” LCD extension board (e.g., ESP-LyraP-LCD32) using the FPC |

### Start Application Development

Before powering up your ESP32-S2-Kaluga-1, please make sure that it is in good condition with no obvious signs of damage.

### Required Hardware

- ESP32-S2-Kaluga-1
- Two USB 2.0 cables (Standard-A to Micro-B)
  - For power supply
  - For UART/JTAG communication
- Computer running Windows, Linux, or macOS
- Any extension boards of your choice

### Hardware Setup

1. Connect the extension board(s) of your choice (go to their respective user guides if necessary)
2. Plug in both USB cables
3. Turn the **Power Switch** to ON - the Power On LED will light up

**Software Setup** Please proceed to Get Started, where Section Installation will quickly help you set up the development environment.

The programming guide and application examples for your ESP32-S2-Kaluga-1 kit can be found in esp-dev-kits repository on GitHub.

A Board Support Package can be found in ESP Component Registry.

### Contents and Packaging

**Retail Orders** If you order one or several samples of the kit, each ESP32-S2-Kaluga-1 development kit comes in an individual package.

The contents are as follows:

- **Main Board**
  - ESP32-S2-Kaluga-1
- **Extension Boards:**
  - ESP-LyraT-8311A
  - ESP-LyraP-CAM
  - ESP-LyraP-TouchA
  - ESP-LyraP-LCD32
- **Connectors**
  - 20-pin FPC cable (to connect ESP32-S2-Kaluga-1 to ESP-LyraP-TouchA)
- **Fasteners**
  - Mounting bolts (x8)
  - Screws (x4)
  - Nuts (x4)

For retail orders, please go to https://www.espressif.com/en/contact-us/get-samples.

**Wholesale Orders** If you order in bulk, the boards come in large cardboard boxes.

For wholesale orders, please go to https://www.espressif.com/en/contact-us/sales-questions.


Fig. 5: ESP32-S2-Kaluga-1 - package

### 5.1.2 Hardware Reference

#### Block Diagram

A block diagram below shows the components of the ESP32-S2-Kaluga-1 and their interconnections.

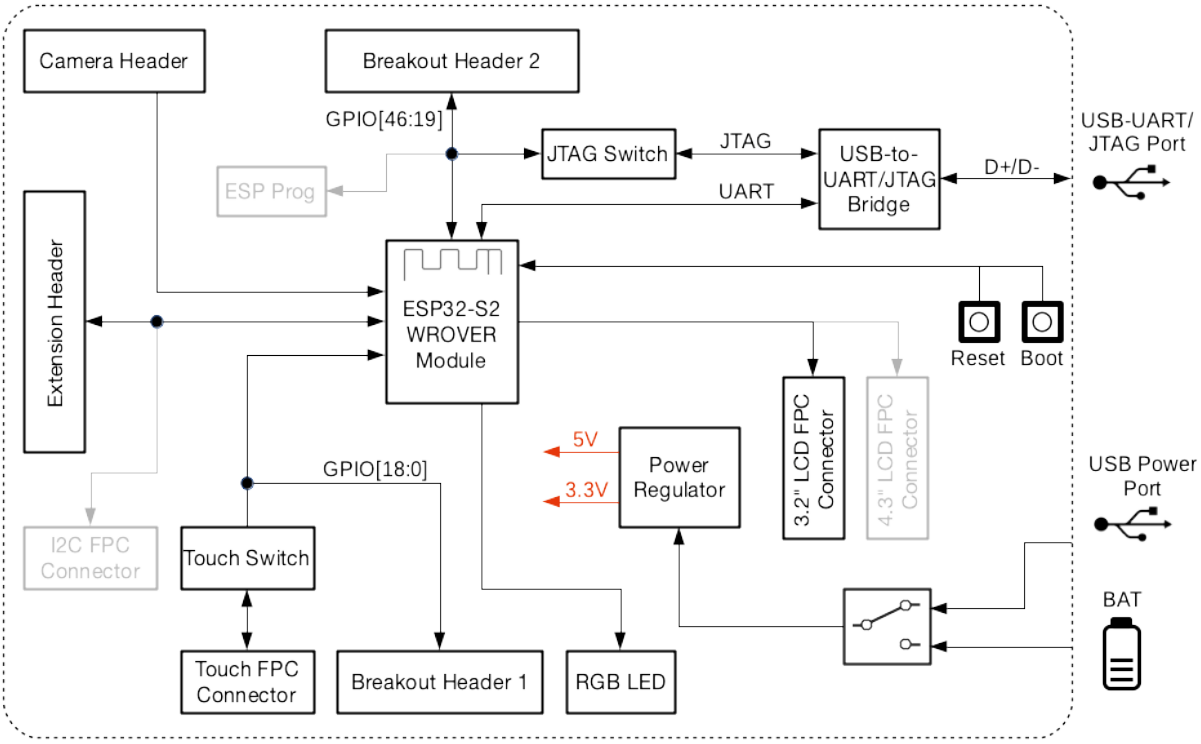



Fig. 6: ESP32-S2-Kaluga-1 block diagram

#### Power Supply Options

There are four ways to provide power to the board:

- Micro USB port, default power supply
- External battery via the 2-pin battery connector
- 5V and GND header pins
- 3V3 and GND header pins

#### Compatibility of Extension Boards

If you want to use more than one extension board at the same time, please check the table given below.

| Boards Used | HW Conflict | Limitations | Solution |
|---|---|---|---|
| 8311A v1.3 + CAM v1.1 | I2S Controller | ESP32-S2 has only one I2S interface. But both extension boards require connection via the ESP32-S2's I2S interface (LyraT-8311A in Standard mode, ESP-LyraP-CAM in Camera mode). | Utilize time division multiple access, or use a different audio module that can be connected via other GPIOs or DAC. |
| TouchA v1.1 + LCD32 v1.2 | IO11, IO6 | Touch actions cannot be triggered because of the multiplexed pin IO11. ESP-LyraP-LCD32 will not be affected because its BLCT pin will be disconnected from IO6. | Do not initialize IO11 (NETWORK) for your ESP-LyraP-TouchA, or configure the BLCT pin to *-1* (= do not use BLCT) for your ESP-LyraP-LCD32. |
| 8311A v1.3 + LCD32 v1.2 | IO6 | BLCT pin of ESP32-S2-Kaluga-1 will be disconnected from IO6. | Configure the BK pin to *-1* (= do not use BLCT) for your ESP-LyraP-LCD32. |
| TouchA v1.1 + 8311A v1.3 | Pin BT_ADC on ESP-LyraT-8311A | This pin is required for initialization of the six button on ESP-LyraT-8311A. At the same time, ESP-LyraP-TouchA needs this pin for its touch actions. | If you plan to use buttons on ESP-LyraT-8311A, do not initialize pin IO6 (PHOTO) for your ESP-LyraP-TouchA. |
| TouchA v1.1 + CAM v1.1 | IO1, IO2, IO3 | Cannot be used simultaneously because of the mentioned multiplexed pins. | For ESP-LyraP-TouchA, do not initialize IO1 (VOL_UP), IO2 (PLAY), and IO3 (VOL_DOWN). |
| TouchA v1.1 + LCD32 v1.2 + CAM v1.1 | IO1, IO2, IO3, IO11 | Conflicts on the mentioned multiplexed pins. | For ESP-LyraP-TouchA, do not initialize IO1 (VOL_UP), IO2 (PLAY), IO3 (VOL_DOWN), and IO11 (NETWORK). |
| TouchA v1.1 + LCD32 v1.2 + 8311A v1.3 | IO6, IO11 | If ESP-LyraT-8311A's pin BT_ADC is used to initialize the board's six buttons, IO6 and IO11 will not be available for the other boards. | Do not initialize IO11 (NETWORK) for your ESP-LyraP-TouchA. Also, if you need to use BT_ADC, do not initialize IO6 (PHOTO). |

Also, all extension boards and the JTAG interface share the same pins IO39, IO40, IO41 and IO42. For this reason, the following may disturb the JTAG operation:

- Plugging in any extension board
- Debugging an application that is using an extension board

### 5.1.3 Hardware Revision Details

#### ESP32-S2-Kaluga-1 Kit v1.3

- The following pins re-assigned to fix the download issue
  - Camera D2: GPIO36
  - Camera D3: GPIO37
  - AU_I2S1_SDI: GPIO34
  - AU_WAKE_INT: GPIO46
- RGB pin header moved to the board's edge
- All dip switches moved to the flip side for convenient operation

#### ESP32-S2-Kaluga-1 Kit v1.2

*Initial release*

### 5.1.4 Related Documents

#### ESP32-S2-Kaluga-1 Kit v1.2

New version available: *ESP32-S2-Kaluga-1 Kit v1.3*

The ESP32-S2-Kaluga-1 kit v1.2 is a development kit by Espressif that is mainly created to:

- Demonstrate the ESP32-S2' s human-computer interaction functionalities
- Provide the users with the tools for development of human-computer interaction applications based on the ESP32-S2

There are many ways of how the ESP32-S2' s abundant functionalities can be used. For starters, the possible use cases may include:

- **Smart home**: From simplest smart lighting, smart door locks, smart sockets, to video streaming devices, security cameras, OTT devices, and home appliances
- **Battery-powered equipment**: Wi-Fi mesh sensor networks, Wi-Fi-networked toys, wearable devices, health management equipment
- **Industrial automation equipment**: Wireless control and robot technology, intelligent lighting, HVAC control equipment, etc.
- **Retail and catering industry**: POS machines and service robots

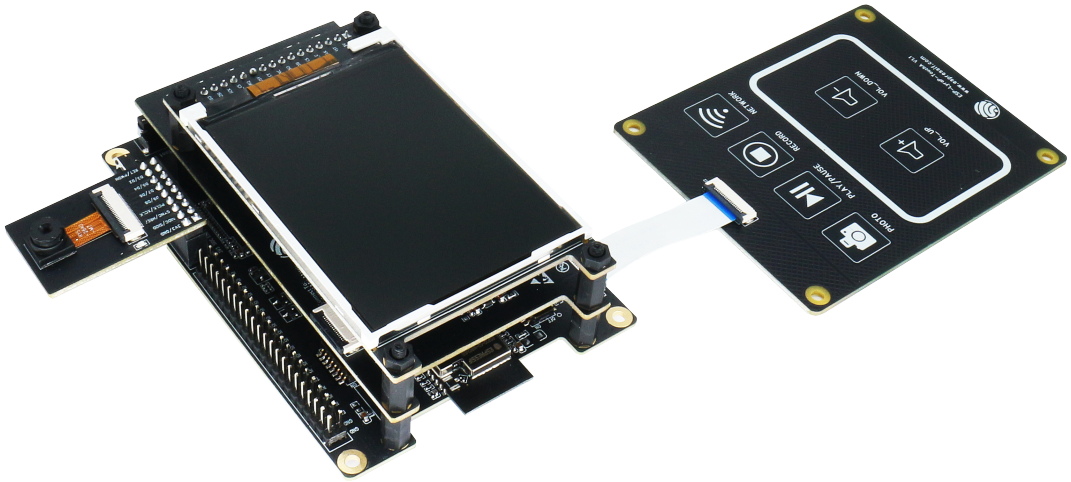


Fig. 7: ESP32-S2-Kaluga-1-Kit Overview (click to enlarge)

The ESP32-S2-Kaluga-1 kit consists of the following boards:

- Main board: *ESP32-S2-Kaluga-1*
- Extension boards:
  - *ESP-LyraT-8311A v1.2* - audio player
  - *ESP-LyraP-TouchA v1.1* - touch panel
  - *ESP-LyraP-LCD32 v1.1* - 3.2" LCD screen
  - *ESP-LyraP-CAM v1.0* - camera board

Due to the presence of multiplexed pins on ESP32-S2, certain extension board combinations have limited compatibility. For more details, please see *Compatibility of Extension Boards*.

This document is **mostly dedicated to the main board** and its interaction with the extension boards. For more detailed information on each extension board, click their respective links.

This guide covers:

- *Getting Started*: Provides an overview of the ESP32-S2-Kaluga-1 and hardware/software setup instructions to get started.
- *Hardware reference*: Provides more detailed information about the ESP32-S2-Kaluga-1 ' s hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP32-S2-Kaluga-1.
- *Related Documents*: Gives links to related documentation.

**Getting Started** This section describes how to get started with the ESP32-S2-Kaluga-1. It begins with a few introductory sections about the ESP32-S2-Kaluga-1, then Section *Start Application Development* provides instructions on how to do the initial hardware setup and then how to flash firmware onto the ESP32-S2-Kaluga-1.

**Overview** The ESP32-S2-Kaluga-1 main board is the heart of the kit. It integrates the ESP32-S2-WROVER module and all the connectors for extension boards. This board is the key tool in prototyping human-computer interaction interfaces.

The ESP32-S2-Kaluga-1 board has connectors for boards with:

- Extension header (ESP-LyraT-8311A, ESP-LyraP-LCD32)
- Camera header (ESP-LyraP-CAM)
- Touch FPC connector (ESP-LyraP-TouchA)
- LCD FPC connector (no official extension boards yet)
- I2C FPC connector (no official extension boards yet)

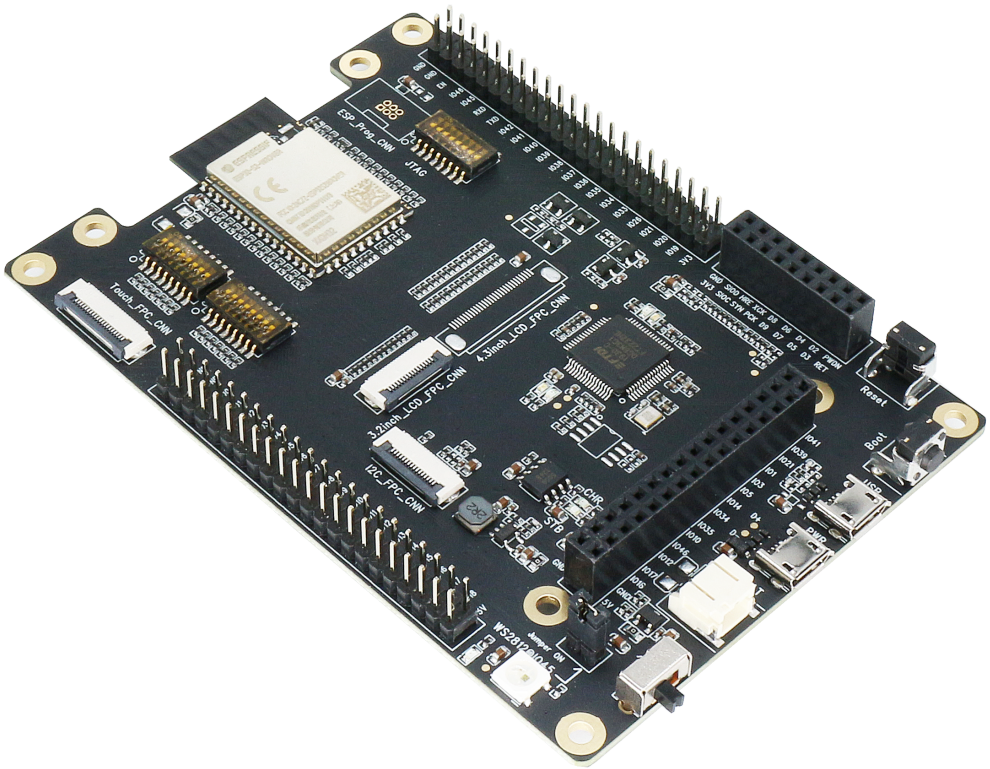



Fig. 8: ESP32-S2-Kaluga-1 (click to enlarge)

All the four extension boards are specially designed to support the following features:

- **Touch panel control**
  - Six touch buttons

  - Supports acrylic panels up to 5 mm
  - Wet hand operation
  - Water rejection, ESP32-S2 can be configured to disable all touchpads automatically if multiple pads are simultaneously covered with water and to re-enable touchpads if the water is removed
- **Audio playback**
  - Connect speakers to play audio
  - Use together with the Touch panel to control audio playback and adjust volume
- **LCD display**
  - LCD interface (8-bit parallel RGB, 8080, and 6800 interface)
- **Camera image acquisition**
  - Supports OV2640 and OV3660 camera modules
  - 8-bit DVP image sensor interface (ESP32-S2 also supports 16-bit DVP image sensors, you can design it yourself)
  - Clock frequency up to 40 MHz
  - Optimized DMA transmission bandwidth for easier transmission of high-resolution images

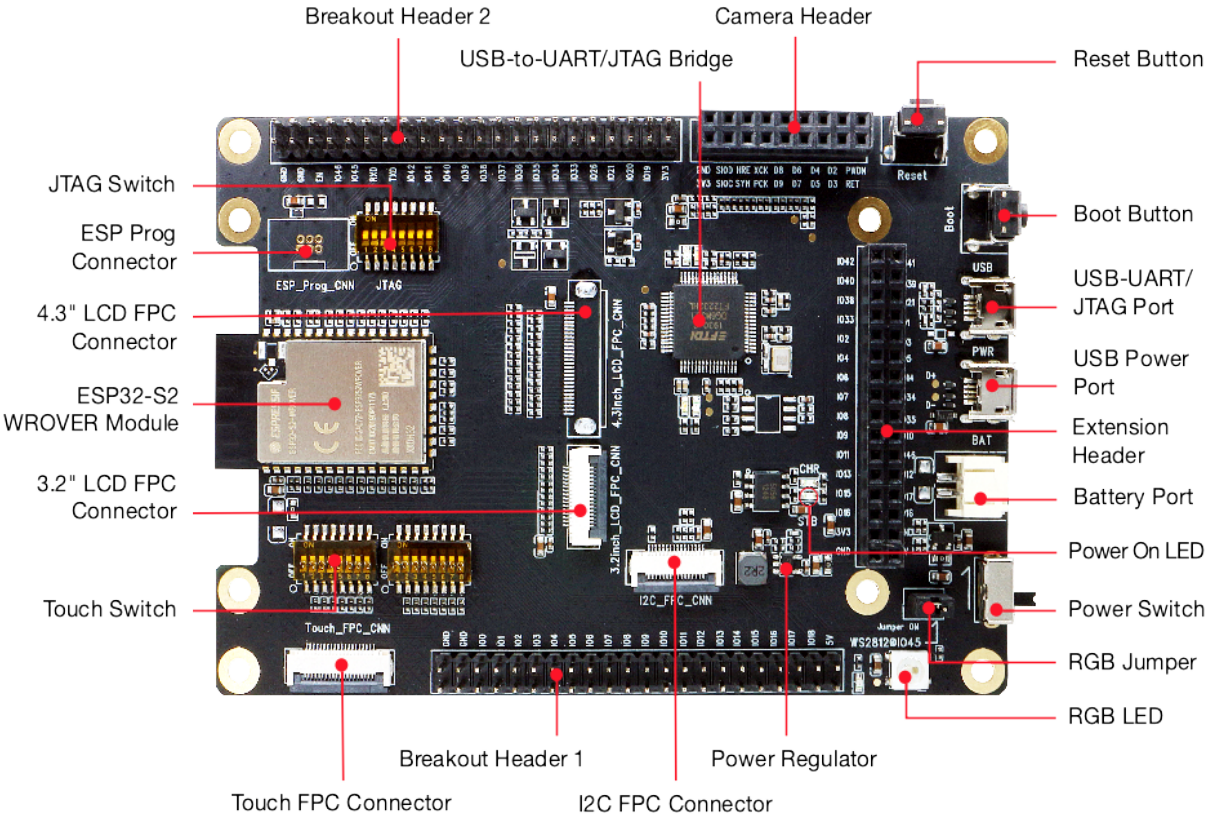



Fig. 9: ESP32-S2-Kaluga-1 - front (click to enlarge)

**Description of Components** The description of components starts from the ESP32-S2 module on the left side and then goes clockwise.

**Reserved** means that the functionality is available, but the current version of the kit does not use it.

| Key Component | Description |
|---|---|
| ESP32-S2-WROVER Module | Module integrating the ESP32-S2 chip that provides Wi-Fi connectivity, data processing power, and flexible data storage. |
| 4.3" LCD FPC Connector | (Reserved) Connect to a 4.3" LCD extension board using the FPC cable. |
| ESP Prog Connector | (Reserved) Connection for Espressif's download device (ESP-Prog) to flash ESP32-S2 system. |
| JTAG Switch | Switch to ON to enable connection between ESP32-S2 and FT2232; JTAG debugging will then be possible using USB-UART/JTAG Port. See also JTAG Debugging. |
| Breakout Header 2 | Some GPIO pins of the ESP32-S2-WROVER module are broken out to this header, see labels on the board. |
| USB-to-UART/JTAG Bridge | FT2232 adapter board allowing for communication over USB port using UART/JTAG protocols. |
| Camera Header | Mount a camera extension board here (e.g., ESP-LyraP-CAM). |
| Extension Header | Mount the extension boards having such connectors here. |
| Reset Button | Press this button to restart the system. |
| Boot Button | Holding down **Boot** and then pressing **Reset** initiates Firmware Download mode for downloading firmware through the serial port. |
| USB-UART/JTAG Port | Communication interface (UART or JTAG) between a PC and the ESP32-S2 module. |
| USB Power Port | Power supply for the board. |
| Battery Port | Connect an external battery to the 2-pin battery connector. |
| Power On LED | Turns on when the USB or an external power supply is connected to the board. |
| Power Switch | Switch to ON to power the system. |
| RGB Jumper | To have access to the RGB LED, place a jumper onto the pins. |
| RGB LED | Programmable RGB LED and controlled by GPIO45. Before using it, you need to put RGB Jumper ON. |
| Power Regulator | Regulator converts 5 V to 3.3 V. |
| I2C FPC Connector | (Reserved) Connect to other I2C extension boards using the FPC cable. |
| Breakout Header 1 | Some GPIO pins of the ESP32-S2-WROVER module are broken out to this header, see labels on the board. |
| Touch FPC Connector | Connect the ESP-LyraP-TouchA extension board using the FPC cable. |
| Touch Switch | In OFF position, GPIO1 to GPIO14 are used for connection to touch sensors; switch to ON if you want to use them for other purposes. |
| 3.2" LCD FPC connector | Connect a 3.2" LCD extension board (e.g., ESP-LyraP-LCD32) using the FPC cable. |

**Start Application Development** Before powering up your ESP32-S2-Kaluga-1, please make sure that it is in good condition with no obvious signs of damage.

### Required Hardware

- ESP32-S2-Kaluga-1
- Two USB 2.0 cables (Standard-A to Micro-B)
  - For power supply
  - For UART/JTAG communication
- Computer running Windows, Linux, or macOS
- Any extension boards of your choice

### Hardware Setup

1. Connect the extension board(s) of your choice (go to their respective user guides if necessary)
2. Plug in both USB cables
3. Turn the **Power Switch** to ON - the Power On LED will light up

**Software Setup** Please proceed to Get Started, where Section Installation will quickly help you set up the development environment.

The programming guide and application examples for your ESP32-S2-Kaluga-1 kit can be found in esp-dev-kits repository on GitHub.

### Contents and Packaging

**Retail Orders** If you order one or several samples of the kit, each ESP32-S2-Kaluga-1 development kit comes in an individual package containing:

- **Main Board**
  - ESP32-S2-Kaluga-1
- **Extension Boards:**
  - ESP-LyraT-8311A
  - ESP-LyraP-CAM
  - ESP-LyraP-TouchA
  - ESP-LyraP-LCD32
- **Connectors**
  - 20-pin FPC cable (to connect ESP32-S2-Kaluga-1 to ESP-LyraP-TouchA)
- **Fasteners**
  - Mounting bolts (x8)
  - Screws (x4)
  - Nuts (x4)

For retail orders, please go to https://www.espressif.com/en/contact-us/get-samples.

**Wholesale Orders** If you order in bulk, the boards come in large cardboard boxes.

For wholesale orders, please go to https://www.espressif.com/en/contact-us/sales-questions.

### Hardware Reference

**Block Diagram** A block diagram below shows the components of the ESP32-S2-Kaluga-1 and their interconnections.

**Power Supply Options** There are four ways to provide power to the board:

- Micro USB port, default power supply
- External battery via the 2-pin battery connector
- 5V and GND header pins
- 3V3 and GND header pins

**Compatibility of Extension Boards** If you want to use more than one extension board at the same time, please check the table given below.

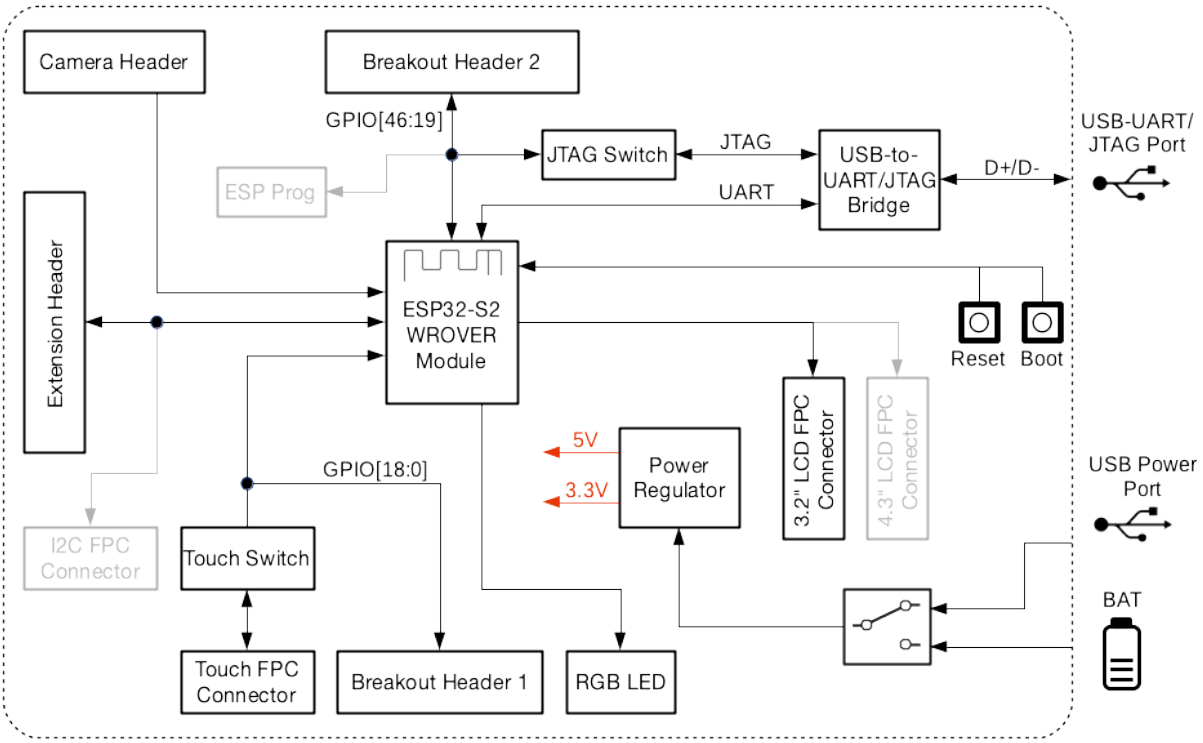



Fig. 10: ESP32-S2-Kaluga-1 block diagram

| Boards Used | HW Conflict | Limitations | Solution |
|---|---|---|---|
| 8311A v1.2 + CAM v1.0 | I2S Controller, IO46 | ESP32-S2 has only one I2S interface. But both extension boards require connection via the ESP32-S2' s I2S interface (ESP-LyraT-8311A in Standard mode, ESP-LyraP-CAM in Camera mode). If IO46 is used by both extension boards at the same time, ESP-LyraP-CAM experiences interferences when used. | No ready solution for now. |
| TouchA v1.1 + LCD32 v1.1 | IO11, IO6 | Touch actions cannot be triggered because of the multiplexed pin IO11. ESP-LyraP-LCD32 is also affected because its BK (BLCT) pin is connected to pin IO6. | Do not initialize IO11 (NETWORK) and IO6 (PHOTO) for your ESP-LyraP-TouchA. |
| 8311A v1.2 + LCD32 v1.1 | IO6 | The two extension boards can be used at the same time. However, since the BK (BLCT) pin of ESP32-S2-Kaluga-1 is connected to IO6, ESP-LyraT-8311A' s pin BT_ADC cannot be used and the board' s six buttons will not be available. | There is a solution that will allow you to use ESP-LyraT-8311A' s pin BT_ADC, but will stop you from controlling the display background brightness with software: on your ESP-LyraP-LCD32 board, remove R39, change R41 to 100 Ohm, switch BLCT_L to on. |
| TouchA v1.1 + 8311A v1.2 | Pin BT_ADC on ESP-LyraT-8311A | The two extension boards can be used at the same time. However, ESP-LyraP-TouchA cannot be triggered if ESP-LyraT-8311A' s pin BT_ADC is used to initialize the board' s six buttons | If you plan to use ESP-LyraT-8311A' s pin BT_ADC, do not initialize pin IO6 (PHOTO) for your ESP-LyraP-TouchA. |
| TouchA v1.1 + CAM v1.0 | IO1, IO2, IO3 | Cannot be used simultaneously because of the mentioned mul- | For ESP-LyraP-TouchA, do not initialize IO1 (VOL_UP), IO2 (PLAY), and IO3 |

Also, all extension boards and the JTAG interface share the same pins IO39, IO40, IO41 and IO42. For this reason, the following may disturb the JTAG operation:

- Plugging in any extension board
- Debugging an application that is using an extension board

### Known Issues

| Hardware Issue | Description | Reason for Failure | Solution |
|---|---|---|---|
| ESP-LyraP-CAM v1.0, pin IO45, IO46 | Flashing firmware might be impossible with the extension board connected to the main board. | Incorrect timing sequence is fed to strapping pins IO45 and IO46 when the board is powered on. It stops the board from booting successfully. | While flashing the main board, keep the extension board disconnected. |
| ESP-LyraP-CAM v1.0, pin IO45, IO46 | Rebooting the board by pressing Reset might not lead to desired results. | Incorrect timing sequence is fed to strapping pins IO45 and IO46 when the board is powered on. It stops the board from booting successfully. | No ready solution for v1.2. This bug is fixed in ESP32-S2-Kaluga-1 V1.3. |
| ESP-LyraT-8311A v1.2, pin IO46 | Flashing firmware might be impossible with the extension board connected to the main board. | Incorrect timing sequence is fed to strapping pin IO46 when the board is powered on. It stops the board from booting successfully. | While flashing the main board, keep the extension board disconnected. |
| ESP-LyraT-8311A v1.2, pin IO46 | Rebooting the board by pressing Reset might not lead to desired results. | Incorrect timing sequence is fed to strapping pin IO46 when the board is powered on. It stops the board from booting successfully. | No ready solution for v1.2. This bug is fixed in ESP32-S2-Kaluga-1 V1.3. |

**Hardware Revision Details** No previous versions available.

### Related Documents

#### ESP-LyraP-CAM v1.0

This user guide provides information on the ESP-LyraP-CAM extension board.

This extension board cannot be bought separately and is usually sold together with other Espressif development boards (e.g., ESP32-S2-Kaluga-1), which will be referred to as *main boards* below.

Currently, ESP-LyraP-CAM v1.0 is sold as part of the *ESP32-S2-Kaluga-1 Kit v1.2*.

The ESP-LyraP-CAM extends the functionality of your main board by adding a camera.

The document consists of the following major sections:

- *Overview*: Provides an overview and hardware/software setup instructions to get started.
- *Hardware reference*: Provides more detailed information about the ESP-LyraP-CAM' s hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP-LyraP-CAM.
- *Related Documents*: Gives links to related documentation.

**Overview** This extension board adds a camera to your main board.

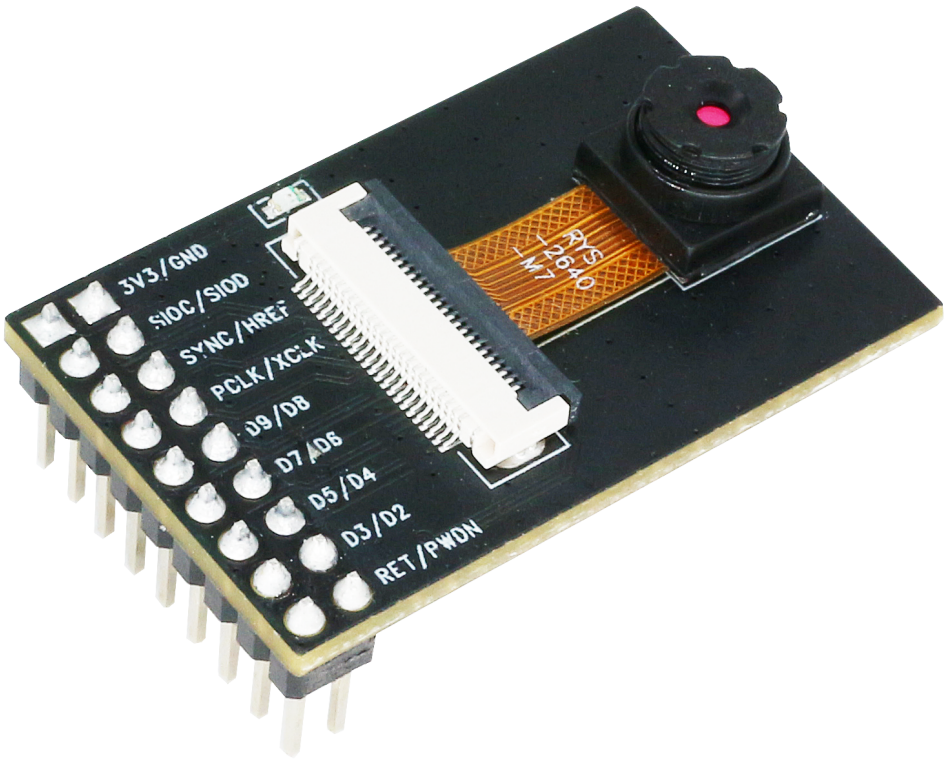



Fig. 11: ESP-LyraP-CAM

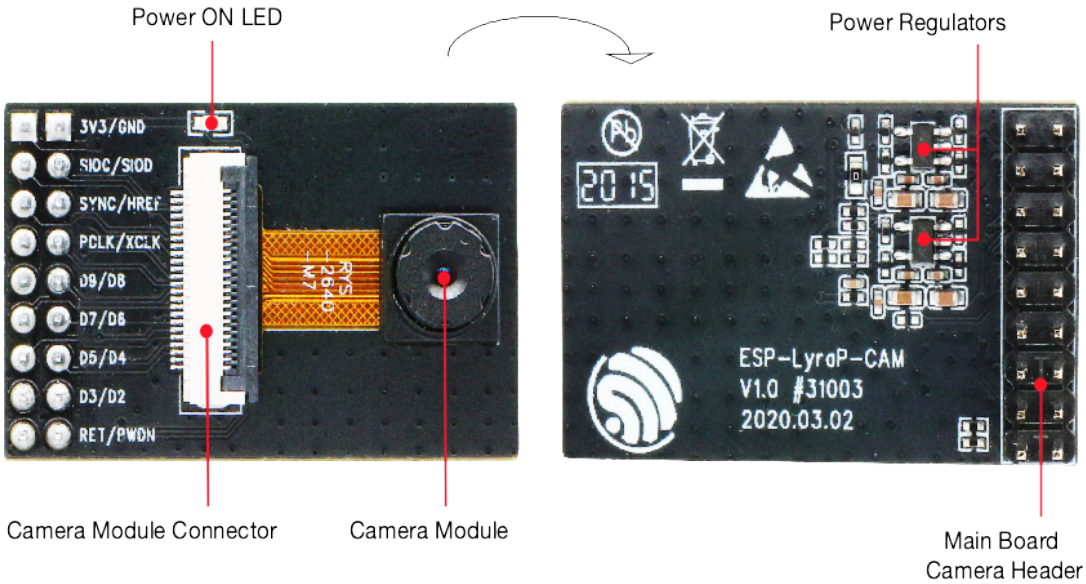



Fig. 12: ESP-LyraP-CAM - front and back

**Description of Components**

| Key Component | Description |
|---|---|
| Main Board Camera Header | Mount onto main board's Camera Header |
| Power ON LED | Red LED is on if the power supply voltage is applied |
| Camera Module Connector | Supports OV2640 and OV3660 camera modules; this extension board is supplied with an OV2640 camera module |
| Power Regulators | LDO Regulators converting 3.3 V to 2.8 V and 1.5 V |

**Start Application Development** Before powering up your ESP-LyraP-CAM, please make sure that it is in good condition with no obvious signs of damage.

**Required Hardware**

- Board with a female Camera Header (e.g., ESP32-S2-Kaluga-1)
- ESP-LyraP-CAM extension board
- Computer running Windows, Linux, or macOS

**Hardware Setup** Insert the ESP-LyraP-CAM extension board into your board's female Camera Header.

**Software Setup** See Section *Software Setup* of the ESP32-S2-Kaluga-1 kit user guide.

**Hardware Reference**

**Block Diagram** A block diagram below shows the components of the ESP-LyraP-CAM and their interconnections.

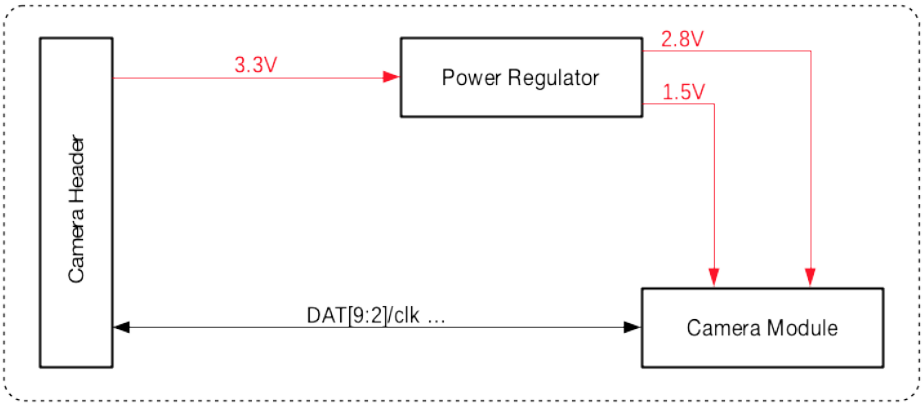



Fig. 13: ESP-LyraP-CAM block diagram

**Hardware Revision Details** No previous versions available.

**Related Documents**

- ESP-LyraP-CAM Schematic (PDF)
- ESP-LyraP-CAM PCB Layout (PDF)
- Camera OV2640 (PDF)

For other design documentation for the board, please contact us at sales@espressif.com.

### ESP-LyraP-LCD32 v1.1

This user guide provides information on the ESP-LyraP-LCD32 extension board.

This extension board cannot be bought separately and is usually sold together with other Espressif development boards (e.g., ESP32-S2-Kaluga-1), which will be referred to as *main boards* below.

Currently, ESP-LyraP-LCD32 v1.1 is sold as part of the *ESP32-S2-Kaluga-1 Kit v1.2*.

The ESP-LyraP-LCD32 extends the functionality of your main board by adding an LCD graphic display.

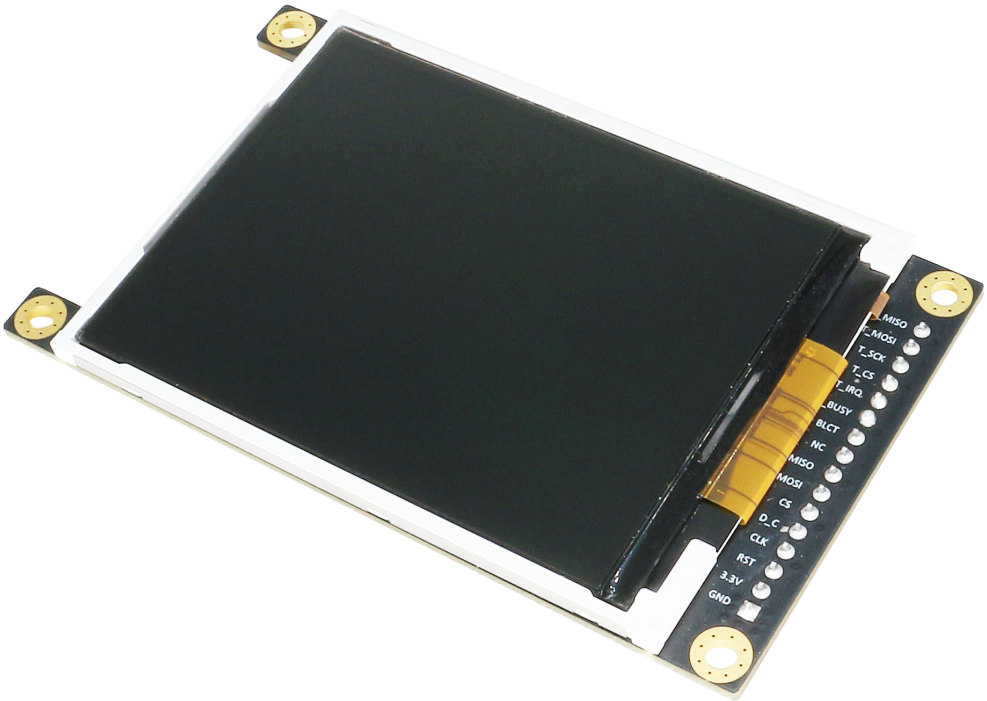



Fig. 14: ESP-LyraP-LCD32 (click to enlarge)

The document consists of the following major sections:

- *Overview*: Provides an overview and hardware/software setup instructions to get started.
- *Hardware reference*: Provides more detailed information about the ESP-LyraP-LCD32 ' s hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP-LyraP-LCD32.
- *Related Documents*: Gives links to related documentation.

**Overview** This extension board adds a 3.2" LCD graphic display with the resolution of 320x240. This display is connected to ESP32-S2 over the SPI bus.

**Description of Components** In the description of components below, **Reserved** means that the functionality is available, but the current version of the kit does not use it.

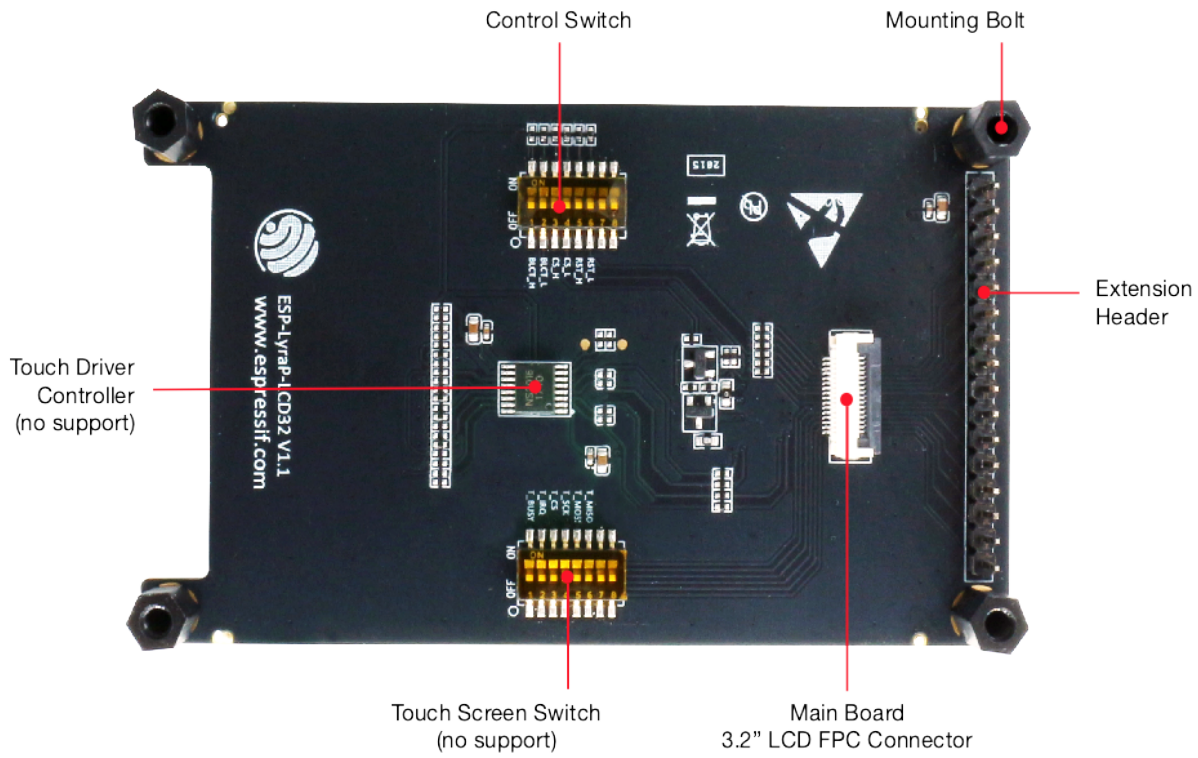



Fig. 15: ESP-LyraP-LCD32 - front (click to enlarge)

| Key Component | Description |
|---|---|
| Extension Header | Male Extension Header for mounting onto a female Extension Header |
| LCD display | This version has a 3.2" 320x240 SPI LCD display module; the display driver/controller is Sitronix ST7789V |
| Touch Screen Switch | No support for touch screens, keep the switches to OFF to make the pins available for other uses |
| Main Board 3.2" LCD FPC Connector | (Reserved) Connect to main board's 3.2" LCD FPC connector |
| Control Switch | Switch to ON to set Reset/Backlight_control/CS to default high or low; switch to OFF to make the pins available for other uses |

**Start Application Development** Before powering up your ESP-LyraP-LCD32, please make sure that it is in good condition with no obvious signs of damage.

### Required Hardware

- Board with a female Extension Header (e.g., ESP32-S2-Kaluga-1, ESP-LyraT-8311A)
- ESP-LyraP-LCD32 extension board
- Four mounting bolts (for stable mounting)
- Computer running Windows, Linux, or macOS

**Hardware Setup** To mount your ESP-LyraP-LCD32 onto the board with a female Extension Header:

1. Install the four mounting bolts onto the board with a female Extension Header
2. Align the ESP-LyraP-LCD32 with the bolts and Extension Header and insert it carefully

**Software Setup** See Section *Software Setup* of the ESP32-S2-Kaluga-1 kit user guide.

### Hardware Reference

**Block Diagram** A block diagram below shows the components of the ESP-LyraP-LCD32 and their interconnections.

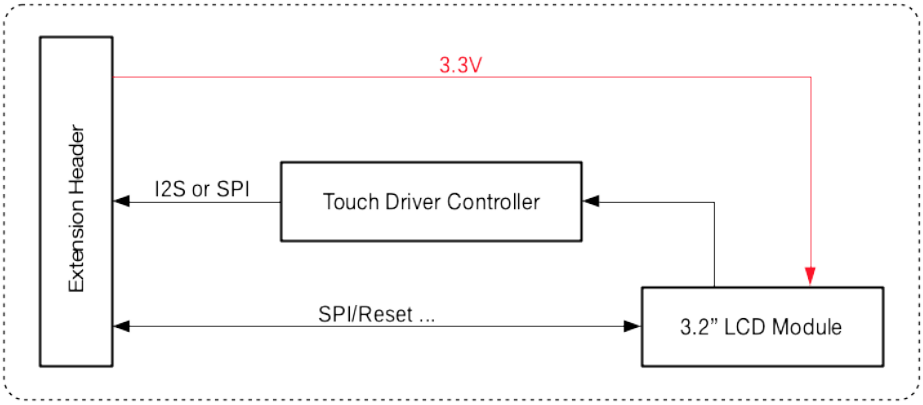



Fig. 16: ESP-LyraP-LCD32 block diagram

**Hardware Revision Details** No previous versions available.

### Related Documents

- ESP-LyraP-LCD32 Schematic (PDF)
- ESP-LyraP-LCD32 PCB Layout (PDF)
- LCD ST7789 (PDF)

For other design documentation for the board, please contact us at sales@espressif.com.

### ESP-LyraP-TouchA v1.1

This user guide provides information on the ESP-LyraP-TouchA extension board.

This board cannot be bought separately and is usually sold together with other Espressif development boards (e.g., ESP32-S2-Kaluga-1), which will be referred to as *main boards* below.

Currently, ESP-LyraP-TouchA v1.1 is sold as part of the following kits:

- *ESP32-S2-Kaluga-1 Kit v1.3*
- *ESP32-S2-Kaluga-1 Kit v1.2*

The ESP-LyraP-TouchA extends the functionality of your main board by adding touch buttons.

The document consists of the following major sections:

- *Overview*: Provides an overview and hardware setup instructions.
- *Hardware reference*: Provides more detailed information about the ESP-LyraP-TouchA's hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP-LyraP-TouchA.
- *Related Documents*: Gives links to related documentation.

**Overview** The ESP-LyraP-TouchA has six touch buttons and is mainly designed for audio applications. However, the touch buttons can also be used for any other purposes.


Fig. 17: ESP-LyraP-TouchA

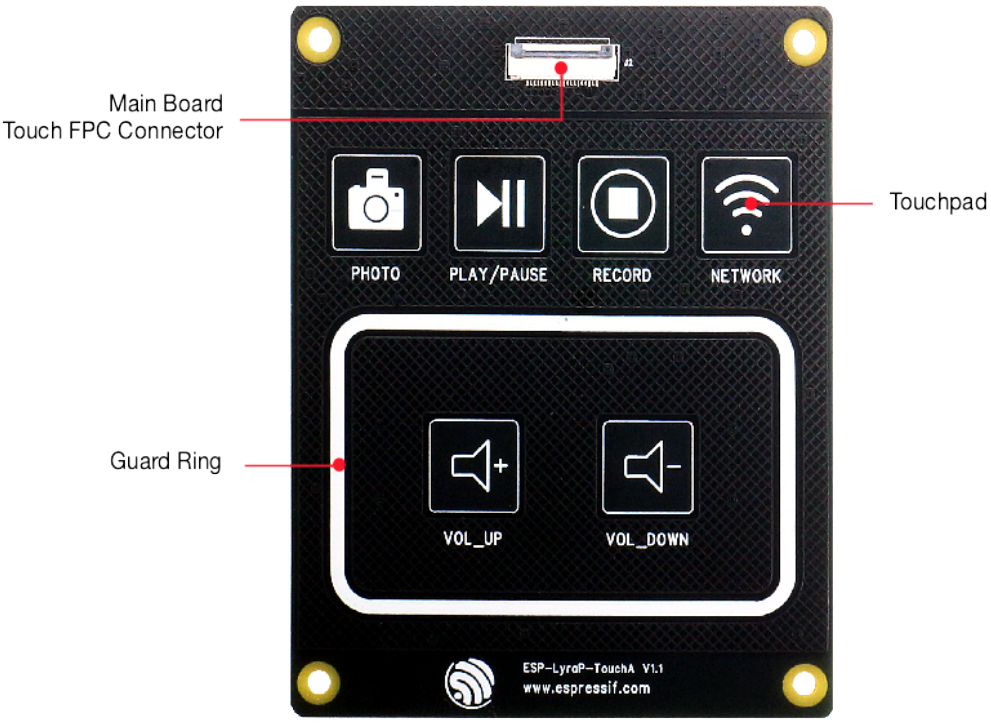



Fig. 18: ESP-LyraP-TouchA

**Description of Components**

| Key Component | Description |
|---|---|
| Main Board Touch FPC Connector | Connect to main board' s Touch FPC Connector. |
| Touchpad | Capacitive touch electrode. |
| Guard Ring | Connected to a touch sensor, the guard ring triggers an interrupt if wet (Water rejection). It indicates that the sensor array is also wet and most (if not all) touchpads are unusable due to the false detection of touches. After receiving this interrupt, the user might consider disabling all the touch sensors via software. |

**Start Application Development** Before powering up your ESP-LyraP-TouchA, please make sure that it is in good condition with no obvious signs of damage.

**Required Hardware**

- Board with a Touch FPC connector (e.g., ESP32-S2-Kaluga-1)
- ESP-LyraP-TouchA extension board
- FPC cable
- Computer running Windows, Linux, or macOS

**Hardware Setup** Connect the two FPC connectors with the FPC cable.

**Software Setup** See Section *Software Setup* of the ESP32-S2-Kaluga-1 kit user guide.

**Hardware Reference**

**Block Diagram** A block diagram below shows the components of ESP-LyraP-TouchA and their interconnections.

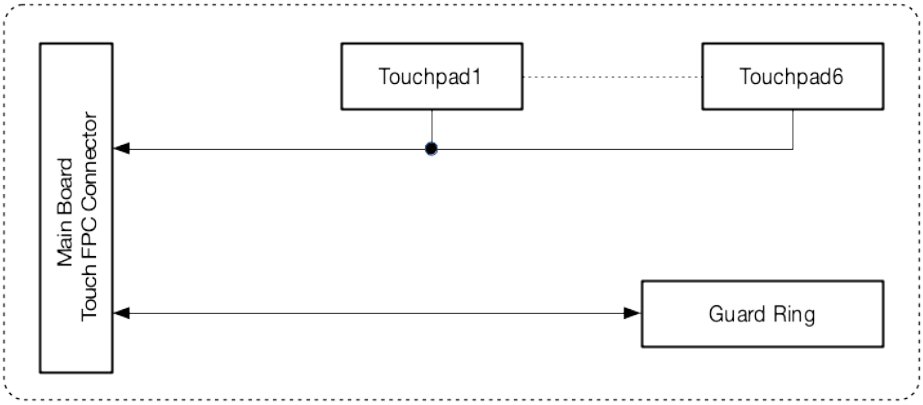



Fig. 19: ESP-LyraP-TouchA-v1.1 block diagram

**Hardware Revision Details** No previous versions available.

### Related Documents

- ESP-LyraP-TouchA Schematic (PDF)
- ESP-LyraP-TouchA PCB Layout (PDF)

For other design documentation for the board, please contact us at sales@espressif.com.

## ESP-LyraT-8311A v1.2

This user guide provides information on the ESP-LyraT-8311A extension board.

This board cannot be bought separately and is usually sold together with other Espressif development boards (e.g., ESP32-S2-Kaluga-1), which will be referred to as *main boards* below.

Currently, ESP-LyraT-8311A v1.2 is sold as part of the *ESP32-S2-Kaluga-1 Kit v1.2*.

The ESP-LyraT-8311A extends the functionality of your main board by adding sound processing functionality:

- Audio playback/recording
- Processing of audio signals
- Programmable buttons for easy control

This extension board can be used in many ways. The applications might include voice user interface, voice control, voice authorization, recording and playback of sound, etc.

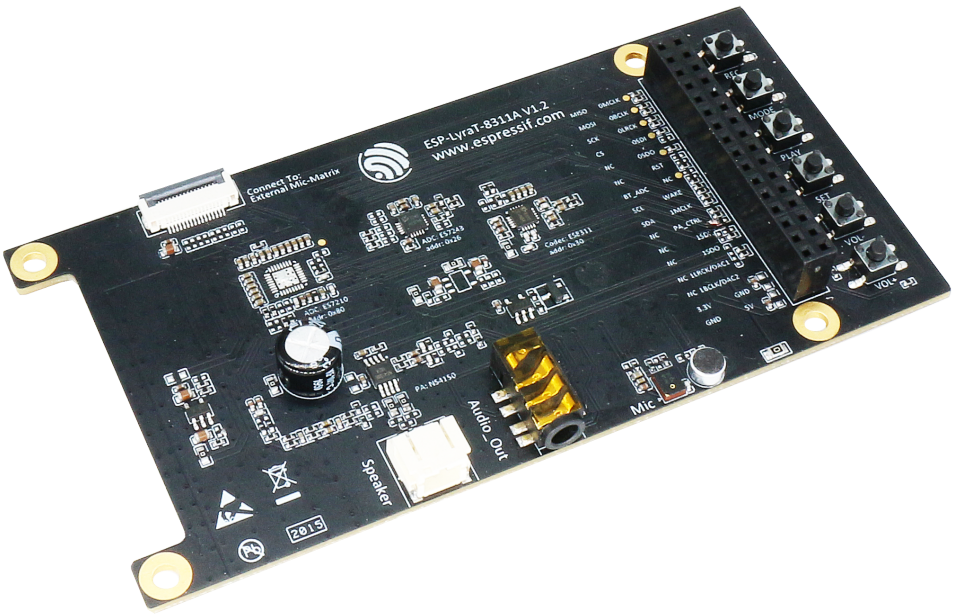



Fig. 20: ESP-LyraT-8311A (click to enlarge)

The document consists of the following major sections:

- *Overview*: Provides an overview and hardware setup instructions.
- *Hardware reference*: Provides more detailed information about the ESP-LyraT-8311A's hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP-LyraT-8311A.
- *Related Documents*: Gives links to related documentation.

**Overview** The ESP-LyraT-8311A is mainly designed for audio applications. However, you can use your creativity to come up with any other use cases.

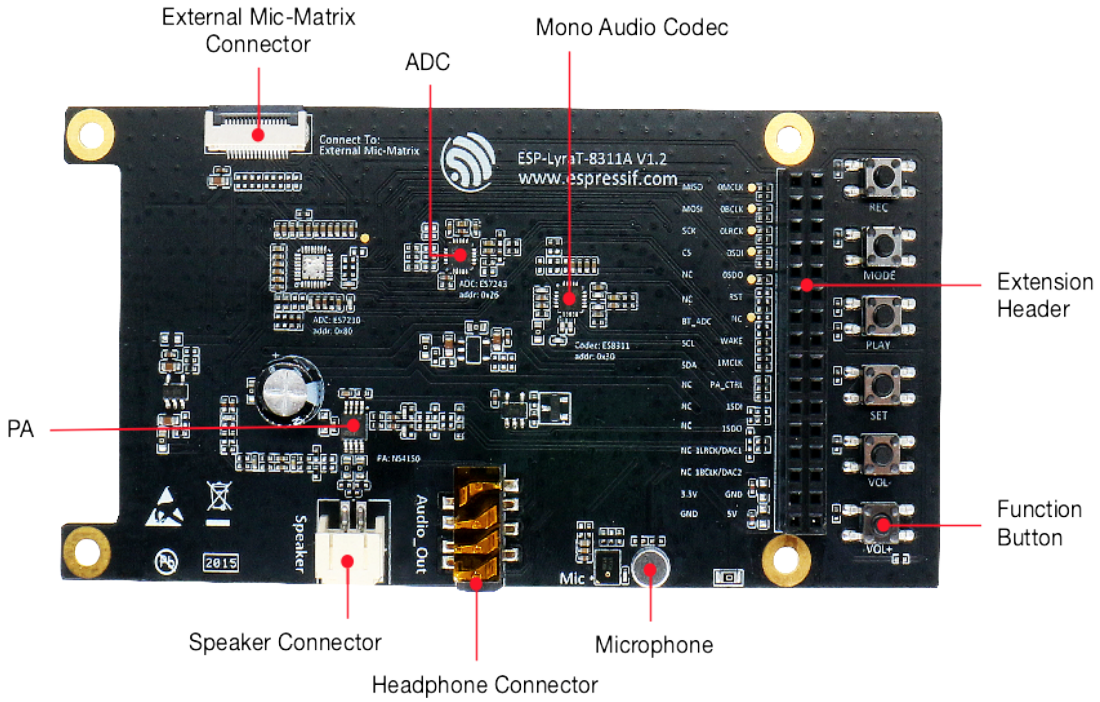



Fig. 21: ESP-LyraT-8311A - front (click to enlarge)

**Description of Components** The description of components starts from the top right corner and then goes clockwise.

**Reserved** means that the functionality is available, but the current version of the kit does not use it.

| Key Component | Description |
|---|---|
| Extension Header | Male Extension Header on the flip side is for mounting onto main board' s Extension Header; Female Extension Header is for mounting other boards that have a Male Extension Header |
| Function Button | This board has six programmable buttons |
| Microphone | Supports Electret and MEMS microphones; this extension board is supplied with an electret microphone |
| Headphone Connector | 6.3 mm (1/8" ) stereo headphone connector |
| Speaker Connector | Connect an external speaker to the 2-pin connector |
| PA | 3 W Audio signal amplifier for the external speaker |
| External Mic-Matrix Connector | (Reserved) FPC connector for external Mic-Matrix (microphone boards) |
| ADC | (Reserved) high-performance ADC/ES7243: 1 channel for microphone, 1 channel for acoustic echo cancellation (AEC) function |
| Mono Audio Codec | ES8311 audio ADC and DAC; it can convert the analog signal picked up by the microphone or convert digital signal to play it back through a speaker or headphones |

**Start Application Development** Before powering up your ESP-LyraT-8311A, please make sure that it is in good condition with no obvious signs of damage.

**Required Hardware**

- Board with a female Extension Header (e.g., ESP32-S2-Kaluga-1)
- ESP-LyraT-8311A extension board
- Four mounting bolts (for stable mounting)
- Computer running Windows, Linux, or macOS

**Hardware Setup** To mount your ESP-LyraT-8311A onto the board with a female Extension Header:

1. Install the four mounting bolts onto the board with a female Extension Header
2. Align the ESP-LyraT-8311A with the bolts and Extension Header and insert it carefully

**Software Setup** Depending on your application, see:

- ESP-ADF Getting Started Guide if you develop with ESP-ADF (Espressif Audio Development Framework).
- Section *Software Setup* of the ESP32-S2-Kaluga-1 kit user guide if you develop directly with ESP-IDF (Espressif IOT Development Framework).

## Hardware Reference

**Block Diagram** A block diagram below shows the components of ESP-LyraT-8311A and their interconnections.

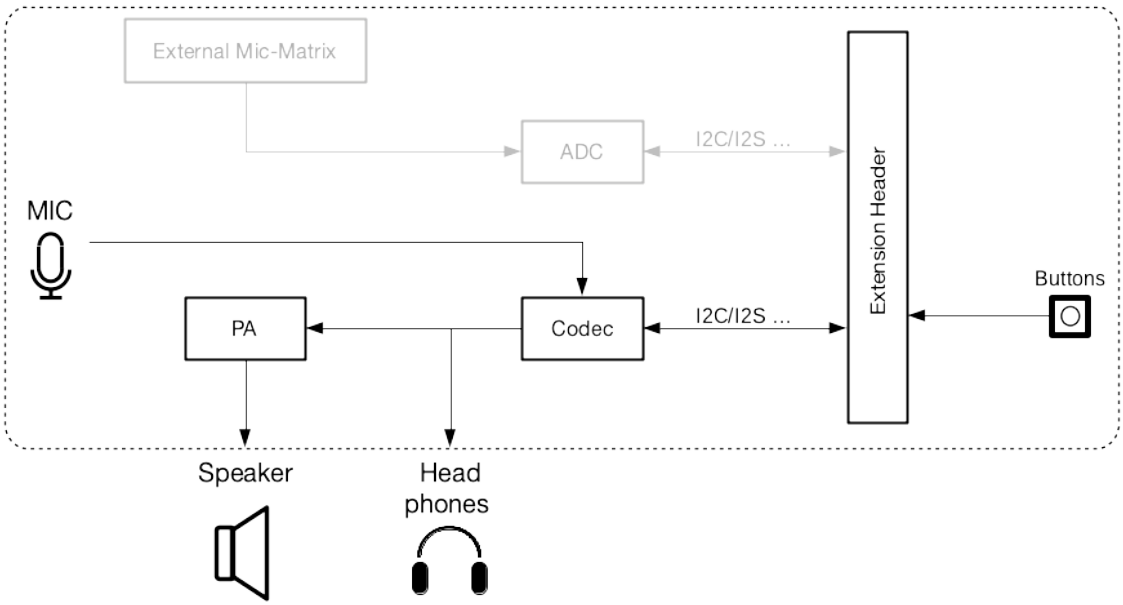



Fig. 22: ESP-LyraT-8311A block diagram

**Hardware Revision Details** No previous versions available.

## Related Documents

- ESP-LyraT-8311A Schematic (PDF)
- ESP-LyraT-8311A PCB Layout (PDF)
- Audio ES8311 (PDF)

For other design documentation for the board, please contact us at sales@espressif.com.

- ESP32-S2 Datasheet (PDF)
- ESP32-S2-WROVER Datasheet (PDF)
- ESP Product Selector

- JTAG Debugging
- ESP32-S2-Kaluga-1 Schematic (PDF)
- ESP32-S2-Kaluga-1 PCB Layout (PDF)
- ESP32-S2-Kaluga-1 Pin Mapping (Excel)

For other design documentation for the board, please contact us at sales@espressif.com.

### ESP-LyraP-CAM v1.1

This user guide provides information on the ESP-LyraP-CAM extension board.

This extension board cannot be bought separately and is usually sold together with other Espressif development boards (e.g., ESP32-S2-Kaluga-1), which will be referred to as *main boards* below.

Currently, ESP-LyraP-CAM v1.1 is sold as part of the *ESP32-S2-Kaluga-1 Kit v1.3*.

The ESP-LyraP-CAM extends the functionality of your main board by adding a camera.

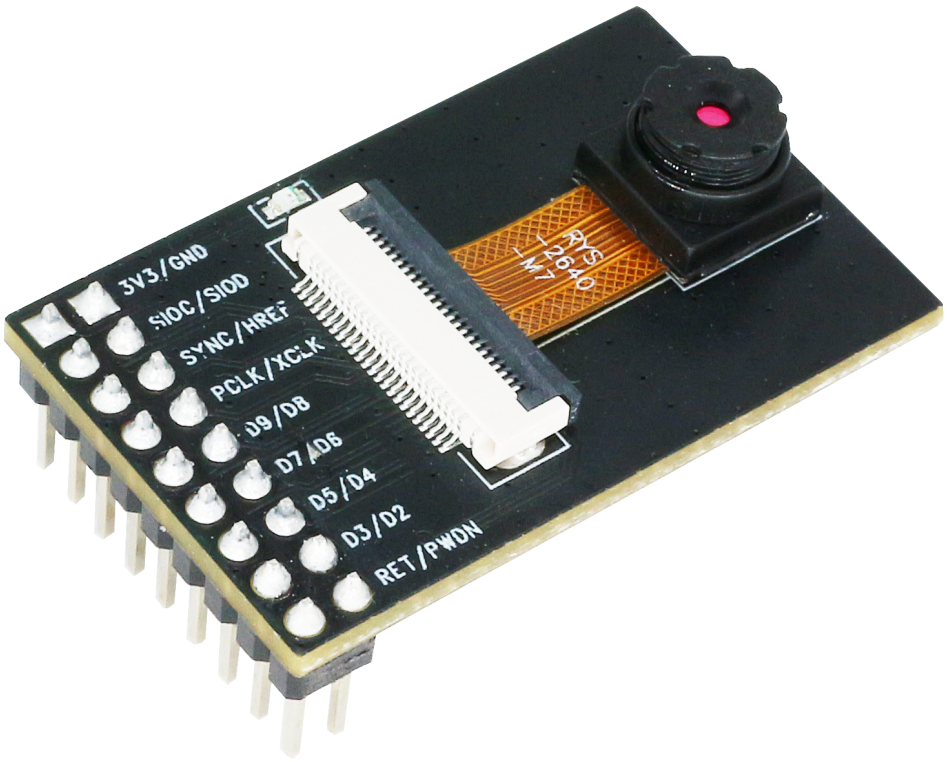



Fig. 23: ESP-LyraP-CAM

The document consists of the following major sections:

- *Overview*: Provides an overview and hardware/software setup instructions to get started.
- *Hardware reference*: Provides more detailed information about the ESP-LyraP-CAM's hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP-LyraP-CAM.
- *Related Documents*: Gives links to related documentation.

**Overview** This extension board adds a camera to your main board.

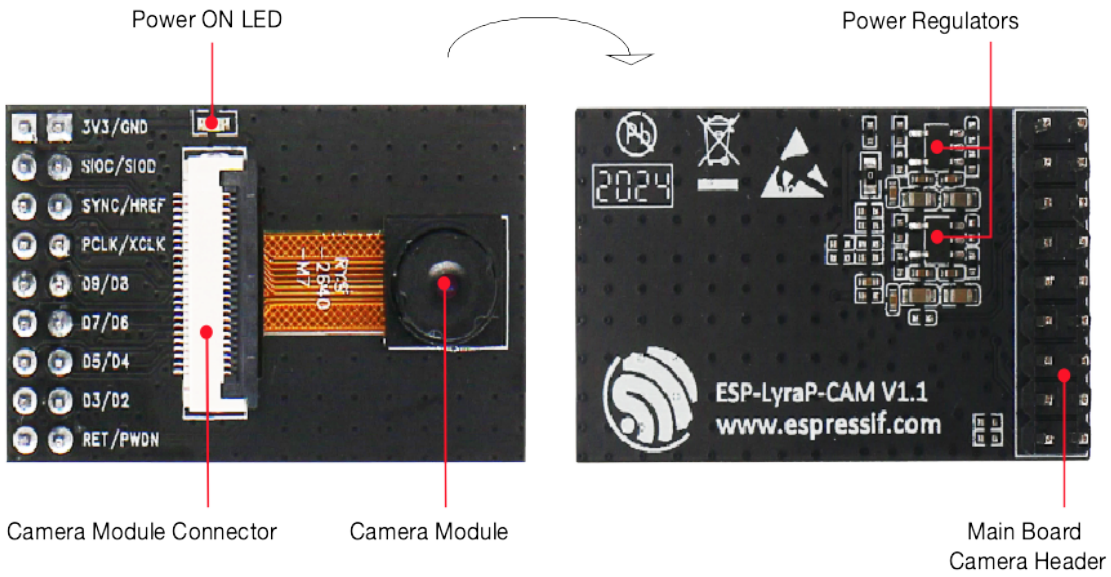



Fig. 24: ESP-LyraP-CAM - front and back

### Description of Components

| Key Component | Description |
|---|---|
| Main Board Camera Header | Mount onto main board’ s Camera Header |
| Power ON LED | Red LED is on if the power supply voltage is correct |
| Camera Module Connector | Supports OV2640 and OV3660 camera modules; this extension board is supplied with an OV2640 camera module |
| Power Regulators | LDO Regulators converting 3.3 V to 2.8 V and 1.5 V |

**Start Application Development** Before powering up your ESP-LyraP-CAM, please make sure that it is in good condition with no obvious signs of damage.

### Required Hardware

- Board with a female Camera Header (e.g., ESP32-S2-Kaluga-1)
- ESP-LyraP-CAM extension board
- Computer running Windows, Linux, or macOS

**Hardware Setup** Insert the ESP-LyraP-CAM extension board into your board’ s female Camera Header.

**Software Setup** See Section *Software Setup* of the ESP32-S2-Kaluga-1 kit user guide.

### Hardware Reference

**Block Diagram** A block diagram below shows the components of the ESP-LyraP-CAM and their interconnections.

### Hardware Revision Details

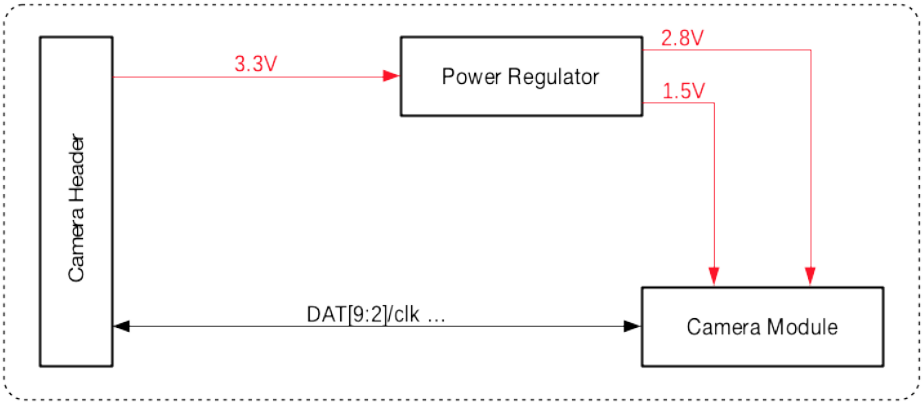



Fig. 25: ESP-LyraP-CAM block diagram

### ESP-LyraP-CAM v1.1

- Silk screen updated
- No actual hardware updates

### ESP-LyraP-CAM v1.0 *Initial release*

### Related Documents

- ESP-LyraP-CAM Schematic (PDF)
- ESP-LyraP-CAM PCB Layout (PDF)
- Camera OV2640 (PDF)

For other design documentation for the board, please contact us at sales@espressif.com.

### ESP-LyraP-LCD32 v1.2

This user guide provides information on the ESP-LyraP-LCD32 extension board.

This extension board cannot be bought separately and is usually sold together with other Espressif development boards (e.g., ESP32-S2-Kaluga-1), which will be referred to as *main boards* below.

Currently, ESP-LyraP-LCD32 v1.2 is sold as part of the *ESP32-S2-Kaluga-1 Kit v1.3*.

The ESP-LyraP-LCD32 extends the functionality of your main board by adding an LCD graphic display.

The document consists of the following major sections:

- *Overview*: Provides an overview and hardware/software setup instructions to get started.
- *Hardware reference*: Provides more detailed information about the ESP-LyraP-LCD32 ' s hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP-LyraP-LCD32.
- *Related Documents*: Gives links to related documentation.

**Overview** This extension board adds a 3.2" LCD graphic display with the resolution of 320x240. This display is connected to ESP32-S2 over the SPI bus.

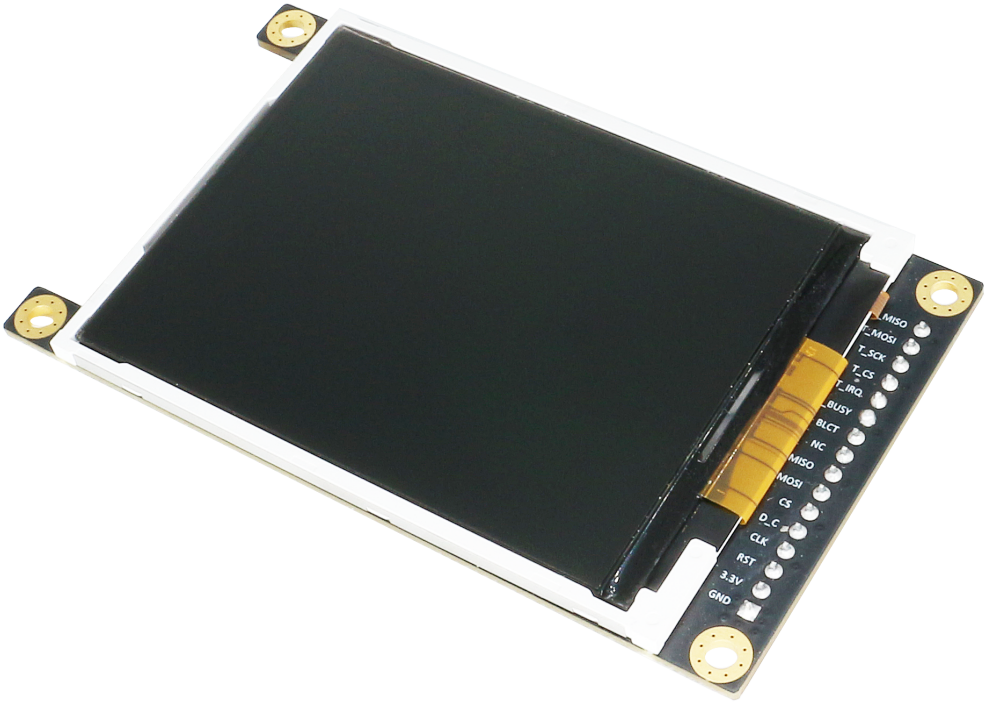



Fig. 26: ESP-LyraP-LCD32 (click to enlarge)


Fig. 27: ESP-LyraP-LCD32 - front (click to enlarge)

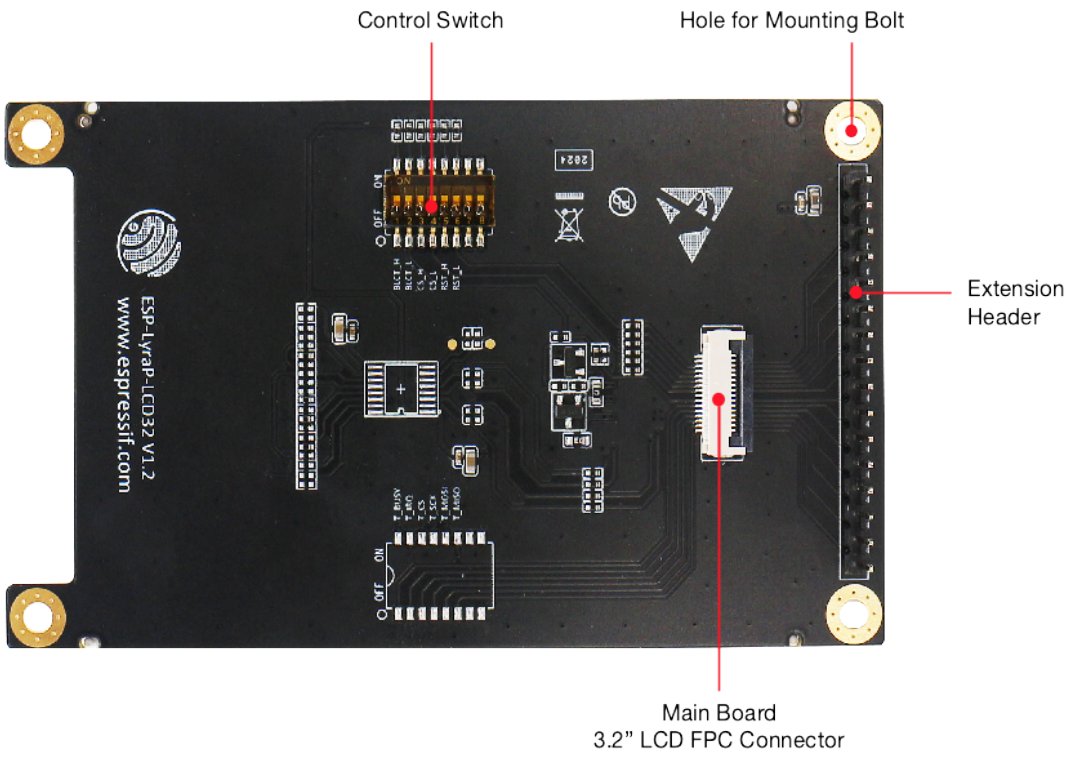



Fig. 28: ESP-LyraP-LCD32 - back (click to enlarge)

**Description of Components** In the description of components below, **Reserved** means that the functionality is available, but the current version of the kit does not use it.

| Key Component | Description |
|---|---|
| Extension Header | Male Extension Header for mounting onto a female Extension Header |
| LCD Display | This version has a 3.2" 320x240 SPI LCD display module; the display driver/controller is either Sitronix ST7789V or Ilitek ILI9341 |
| Touch Screen Switch | No support for touch screens, keep the switches to OFF to make the pins available for other uses |
| Main Board 3.2" LCD FPC Connector | (Reserved) Connect to main board's 3.2" LCD FPC connector |
| Control Switch | Switch to ON to set Reset/Backlight_control/CS to default high or low; switch to OFF to make the pins available for other uses |

**Start Application Development** Before powering up your ESP-LyraP-LCD32, please make sure that it is in good condition with no obvious signs of damage.

### Required Hardware

- Board with a female Extension Header (e.g., ESP32-S2-Kaluga-1, ESP-LyraT-8311A)
- ESP-LyraP-LCD32 extension board
- Four mounting bolts (for stable mounting)
- Computer running Windows, Linux, or macOS

**Hardware Setup** To mount your ESP-LyraP-LCD32 onto the board with a female Extension Header:

1. Install the four mounting bolts onto the board with a female Extension Header
2. Align the ESP-LyraP-LCD32 with the bolts and Extension Header and insert it carefully

**Software Setup** See Section *Software Setup* of the ESP32-S2-Kaluga-1 kit user guide.

### Hardware Reference

**Block Diagram** A block diagram below shows the components of the ESP-LyraP-LCD32 and their interconnections.

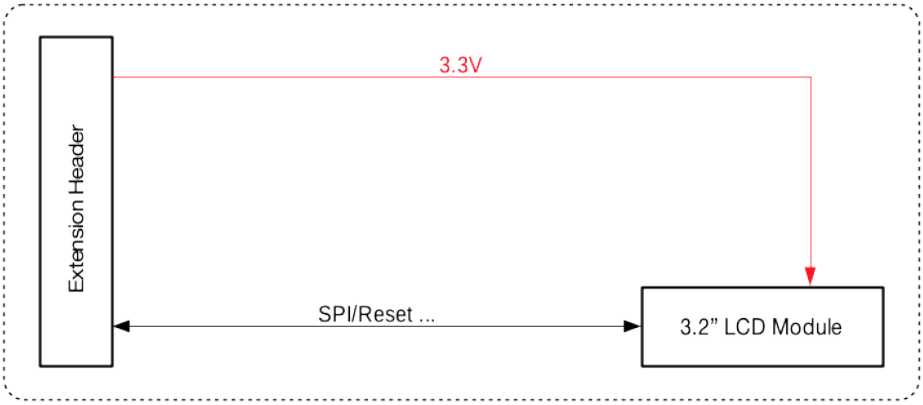



Fig. 29: ESP-LyraP-LCD32 block diagram

### Hardware Revision Details

#### ESP-LyraP-LCD32 v1.2

- LCD backlight default ON, cannot be controlled by MCU
- Touch Driver and related switch removed for major limitations caused by multiplexed pins

#### ESP-LyraP-LCD32 v1.1 *Initial release*

### Related Documents

- ESP-LyraP-LCD32 Schematic (PDF)
- ESP-LyraP-LCD32 PCB Layout (PDF)
- LCD ST7789 (PDF)

For other design documentation for the board, please contact us at sales@espressif.com.

#### ESP-LyraT-8311A v1.3

This user guide provides information on the ESP-LyraT-8311A extension board.

This board cannot be bought separately and is usually sold together with other Espressif development boards (e.g., ESP32-S2-Kaluga-1), which will be referred to as *main boards* below.

Currently, ESP-LyraT-8311A v1.3 is sold as part of the *ESP32-S2-Kaluga-1 Kit v1.3*.

The ESP-LyraT-8311A extends the functionality of your main board by adding sound processing functionality:

- Audio playback/recording
- Processing of audio signals
- Programmable buttons for easy control

This extension board can be used in many ways. The applications might include voice user interface, voice control, voice authorization, recording and playback of sound, etc.

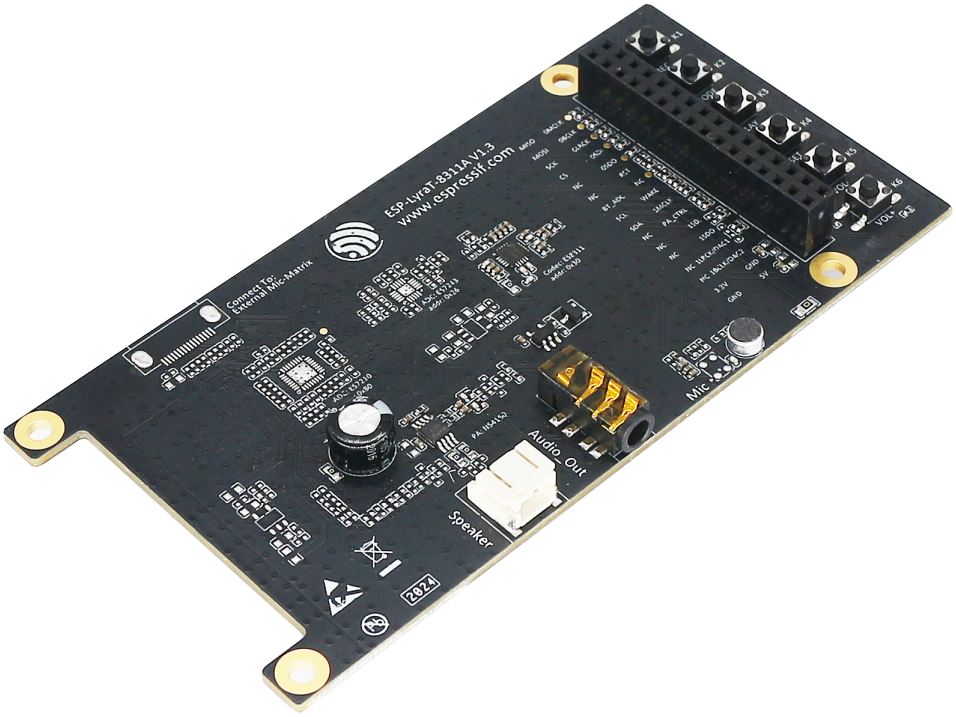



Fig. 30: ESP-LyraT-8311A (click to enlarge)

The document consists of the following major sections:

- *Overview*: Provides an overview and hardware setup instructions.
- *Hardware reference*: Provides more detailed information about the ESP-LyraT-8311A's hardware.
- *Hardware Revision Details*: Covers revision history, known issues, and links to user guides for previous versions of the ESP-LyraT-8311A.
- *Related Documents*: Gives links to related documentation.

**Overview** The ESP-LyraT-8311A is mainly designed for audio applications. However, you can use your creativity to come up with any other use cases.

**Description of Components** The description of components starts from the top right corner and then goes clockwise.

**Reserved** means that the functionality is available, but the current version of the kit does not use it.

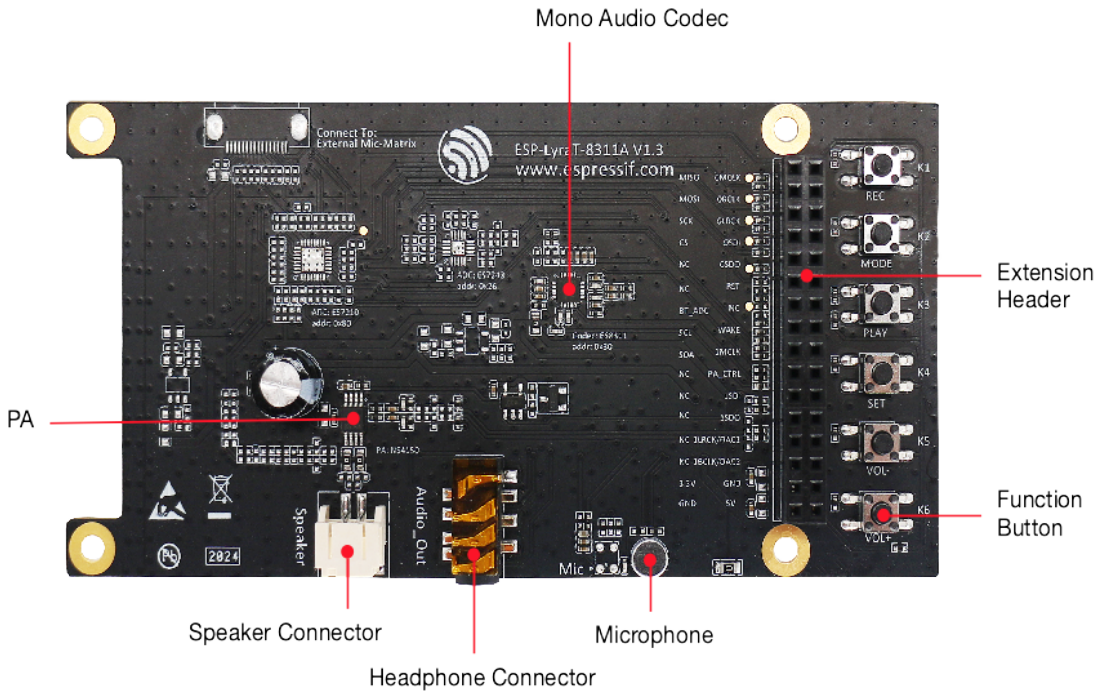



Fig. 31: ESP-LyraT-8311A - front (click to enlarge)

| Key Component | Description |
|---|---|
| Extension Header | Male Extension Header on the flip side is for mounting onto main board' s Extension Header; Female Extension Header is for mounting other boards that have a Male Extension Header |
| Function Button | This board has six programmable buttons |
| Microphone | Supports Electret and MEMS microphones; this extension board is supplied with an electret microphone |
| Headphone Connector | 6.3 mm (1/8" ) stereo headphone connector |
| Speaker Connector | Connect an external speaker to the 2-pin connector |
| PA | 3 W Audio signal amplifier for the external speaker |
| External Mic-Matrix Connector | (Reserved) FPC connector for external Mic-Matrix (microphone boards) |
| ADC | (Reserved) high-performance ADC/ES7243: 1 channel for microphone, 1 channel for acoustic echo cancellation (AEC) function |
| Mono Audio Codec | ES8311 audio ADC and DAC; it can convert the analog signal picked up by the microphone or convert digital signal to play it back through a speaker or headphones |

**Start Application Development** Before powering up your ESP-LyraT-8311A, please make sure that it is in good condition with no obvious signs of damage.

### Required Hardware

- Board with a female Extension Header (e.g., ESP32-S2-Kaluga-1)
- ESP-LyraT-8311A extension board
- Four mounting bolts (for stable mounting)
- Computer running Windows, Linux, or macOS

**Hardware Setup** To mount your ESP-LyraT-8311A onto the board with a female Extension Header:

1. Install the four mounting bolts onto the board with a female Extension Header
2. Align the ESP-LyraT-8311A with the bolts and Extension Header and insert it carefully

**Software Setup** Depending on your application, see:

- ESP-ADF Getting Started Guide if you develop with ESP-ADF (Espressif Audio Development Framework).
- Section *Software Setup* of the ESP32-S2-Kaluga-1 kit user guide if you develop directly with ESP-IDF (Espressif IOT Development Framework).

### Hardware Reference

**Block Diagram** A block diagram below shows the components of ESP-LyraT-8311A and their interconnections.

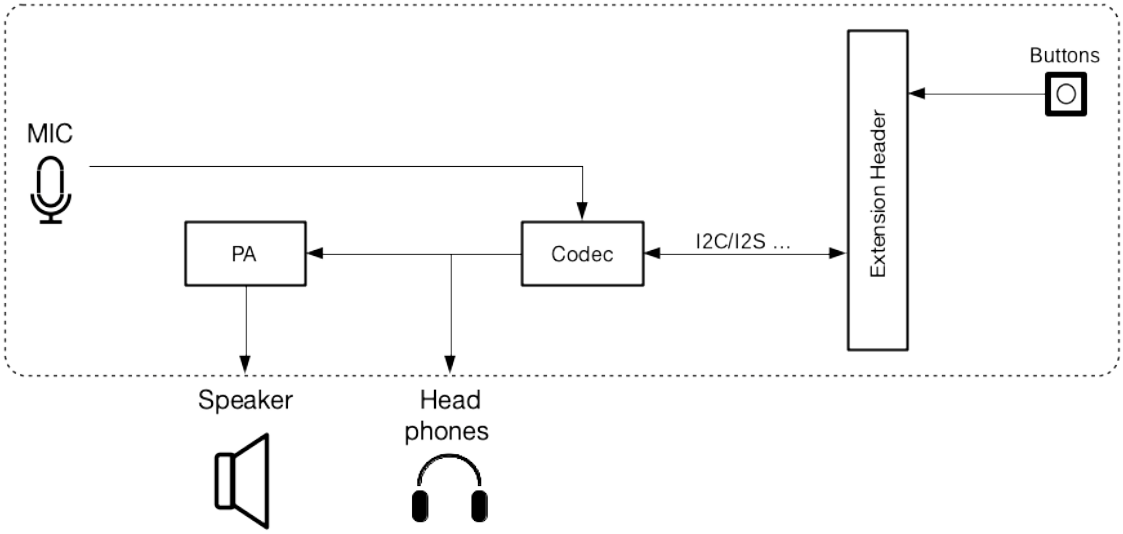



Fig. 32: ESP-LyraT-8311A block diagram

### Hardware Revision Details

#### ESP-LyraT-8311A v1.3

- ADC/ES7243 and ADC/ES7210 removed as the Mono Audio Codec chip provides all the needed functionality.

#### ESP-LyraT-8311A v1.2 *Initial release*

### Related Documents

- ESP-LyraT-8311A Schematic (PDF)
- ESP-LyraT-8311A PCB Layout (PDF)
- Audio ES8311 (PDF)

For other design documentation for the board, please contact us at sales@espressif.com.

- ESP32-S2 Datasheet (PDF)
- ESP32-S2-WROVER Datasheet (PDF)
- ESP Product Selector
- JTAG Debugging
- ESP32-S2-Kaluga-1 Schematic (PDF)

- ESP32-S2-Kaluga-1 PCB Layout (PDF)
- ESP32-S2-Kaluga-1 Pin Mapping (Excel)

For other design documentation for the board, please contact us at sales@espressif.com.

# Chapter 6

# ESP32-S2-Saola-1

ESP32-S2-Saola-1 is a small-sized ESP32-S2 based development board produced by Espressif. Most of the I/O pins are broken out to the pin headers on both sides for easy interfacing. Developers can either connect peripherals with jumper wires or mount ESP32-S2-Saola-1 on a breadboard.

## 6.1 ESP32-S2-Saola-1

This user guide provides information on ESP32-S2-Saola-1, a small-sized ESP32-S2 Datasheet based development board produced by Espressif.

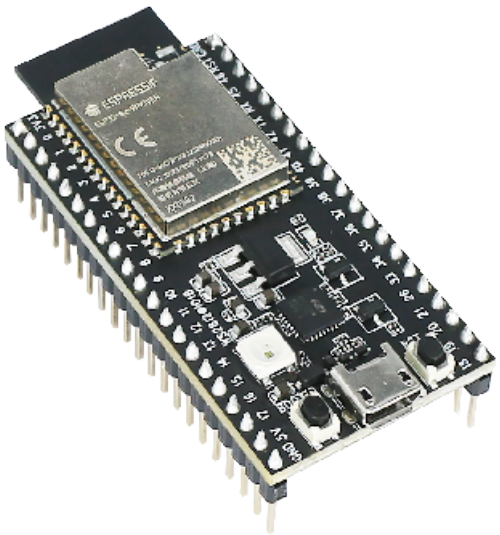


Fig. 1: ESP32-S2-Saola-1

The document consists of the following major sections:

- *Getting started*: Provides an overview of the ESP32-S2-Saola-1 and hardware/software setup instructions to get started.
- *Hardware reference*: Provides more detailed information about the ESP32-S2-Saola-1 ' s hardware.
- *Hardware Revision Details*: Revision history, known issues, and links to user guides for previous versions (if any) of ESP32-S2-Saola-1.
- *Related Documents*: Gives links to related documentation.

### 6.1.1 Getting Started

This section describes how to get started with ESP32-S2-Saola-1. It begins with a few introductory sections about the ESP32-S2-Saola-1, then Section *Start Application Development* provides instructions on how to get the ESP32-S2-Saola-1 ready and flash firmware into it.

#### Overview

ESP32-S2-Saola-1 is a small-sized ESP32-S2 based development board produced by Espressif. Most of the I/O pins are broken out to the pin headers on both sides for easy interfacing. Developers can either connect peripherals with jumper wires or mount ESP32-S2-Saola-1 on a breadboard.

To cover a wide range of users' needs, ESP32-S2-Saola-1 supports:

- ESP32-S2-WROVER
- ESP32-S2-WROVER-I
- ESP32-S2-WROOM
- ESP32-S2-WROOM-I

In this guide, we take ESP32-S2-Saola-1 equipped with ESP32-S2-WROVER as an example.

#### Contents and Packaging

**Retail Orders** If you order a few samples, each ESP32-S2-Saola-1 comes in an individual package in either anti-static bag or any packaging depending on your retailer.

For retail orders, please go to https://www.espressif.com/en/contact-us/get-samples.

**Wholesale Orders** If you order in bulk, the boards come in large cardboard boxes.

For wholesale orders, please go to https://www.espressif.com/en/contact-us/sales-questions.

#### Description of Components

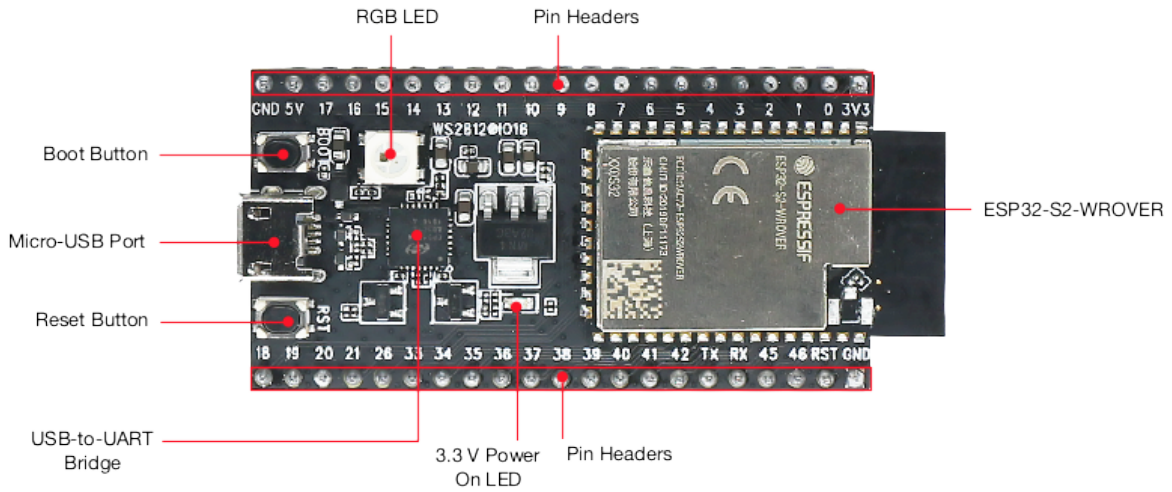



Fig. 2: ESP32-S2-Saola-1 - front

The key components of the board are described in a clockwise direction.

| Key Component | Description |
|---|---|
| ESP32-S2-WROVER | ESP32-S2-WROVER is a powerful, generic Wi-Fi MCU module that integrates ESP32-S2. It has a PCB antenna, a 4 MB external SPI flash and an additional 2 MB PSRAM. |
| Pin Headers | All available GPIO pins (except for the SPI bus for flash and PSRAM) are broken out to the pin headers on the board. Users can program ESP32-S2 chip to enable multiple functions such as SPI, I2S, UART, I2C, touch sensors, PWM etc. |
| 3.3 V Power On LED | Turns on when the USB power is connected to the board. |
| USB-to-UART Bridge | Single USB-UART bridge chip provides transfer rates up to 3 Mbps. |
| Reset Button | Reset button. |
| Micro-USB Port | USB interface. Power supply for the board as well as the communication interface between a computer and the ESP32-S2 chip. |
| Boot Button | Download button. Holding down **Boot** and then pressing **Reset** initiates Firmware Download mode for downloading firmware through the serial port. |
| RGB LED | Addressable RGB LED (WS2812), driven by GPIO18. |

#### Start Application Development

Before powering up your ESP32-S2-Saola-1, please make sure that it is in good condition with no obvious signs of damage.

#### Required Hardware

- ESP32-S2-Saola-1
- USB 2.0 cable (Standard-A to Micro-B)
- Computer running Windows, Linux, or macOS

---

**Note:** Be sure to use an appropriate USB cable. Some cables are for charging only and do not provide the needed data lines nor work for programming the boards.

---

**Software Setup** Please proceed to Get Started, where Section Installation will quickly help you set up the development environment and then flash an application example into your ESP32-S2-Saola-1.

---

**Note:** ESP32-S2 series of chips only supports ESP-IDF master or version v4.2 and higher.

---

### 6.1.2 Hardware Reference

#### Block Diagram

A block diagram below shows the components of ESP32-S2-Saola-1 and their interconnections.

**Power Supply Options** There are three mutually exclusive ways to provide power to the board:

- Micro-USB port, default power supply
- 5V and GND pin headers
- 3V3 and GND pin headers

It is recommended to use the first option: Micro-USB Port.

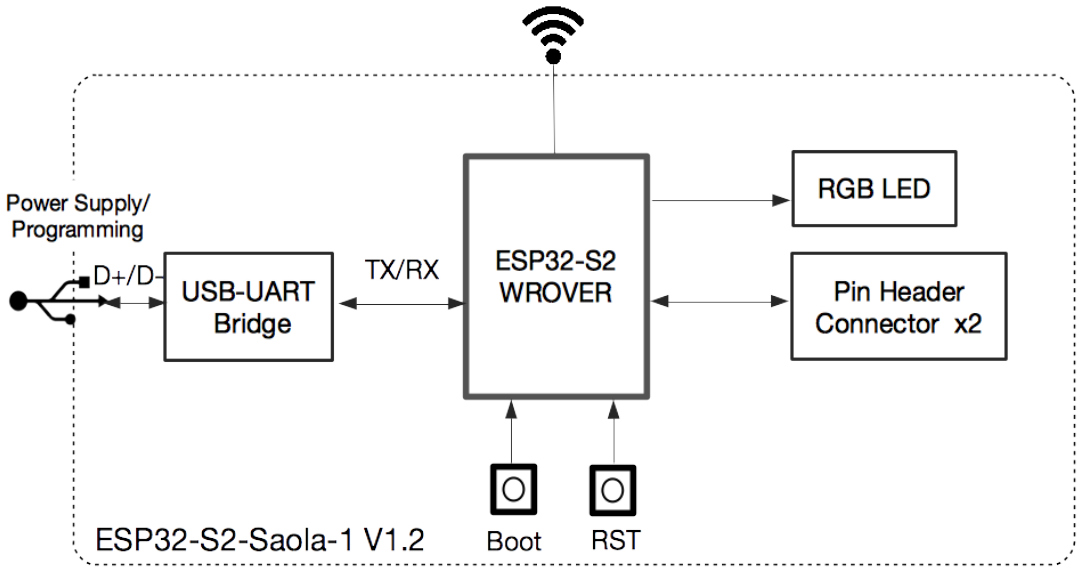



Fig. 3: ESP32-S2-Saola-1 (click to enlarge)

### Header Block

The two tables below provide the **Name** and **Function** of the pin headers on both sides of the board (J2 and J3). The pin header names are shown in *ESP32-S2-Saola-1 - front*. The numbering is the same as in the ESP32-S2-Saola-1 Schematics (PDF).

**J2**

| No. | Name | Type[1] | Function |
|---|---|---|---|
| 1 | 3V3 | P | 3.3 V power supply |
| 2 | IO0 | I/O | GPIO0, Boot |
| 3 | IO1 | I/O | GPIO1, ADC1_CH0, TOUCH_CH1 |
| 4 | IO2 | I/O | GPIO2, ADC1_CH1, TOUCH_CH2 |
| 5 | IO3 | I/O | GPIO3, ADC1_CH2, TOUCH_CH3 |
| 6 | IO4 | I/O | GPIO4, ADC1_CH3, TOUCH_CH4 |
| 7 | IO5 | I/O | GPIO5, ADC1_CH4, TOUCH_CH5 |
| 8 | IO6 | I/O | GPIO6, ADC1_CH5, TOUCH_CH6 |
| 9 | IO7 | I/O | GPIO7, ADC1_CH6, TOUCH_CH7 |
| 10 | IO8 | I/O | GPIO8, ADC1_CH7, TOUCH_CH8 |
| 11 | IO9 | I/O | GPIO9, ADC1_CH8, TOUCH_CH9 |
| 12 | IO10 | I/O | GPIO10, ADC1_CH9, TOUCH_CH10 |
| 13 | IO11 | I/O | GPIO11, ADC2_CH0, TOUCH_CH11 |
| 14 | IO12 | I/O | GPIO12, ADC2_CH1, TOUCH_CH12 |
| 15 | IO13 | I/O | GPIO13, ADC2_CH2, TOUCH_CH13 |
| 16 | IO14 | I/O | GPIO14, ADC2_CH3, TOUCH_CH14 |
| 17 | IO15 | I/O | GPIO15, ADC2_CH4, XTAL_32K_P |
| 18 | IO16 | I/O | GPIO16, ADC2_CH5, XTAL_32K_N |
| 19 | IO17 | I/O | GPIO17, ADC2_CH6, DAC_1 |
| 20 | 5V0 | P | 5 V power supply |
| 21 | GND | G | Ground |

[1] P: Power supply; I: Input; O: Output; T: High impedance.

**J3**

| No. | Name | Type | Function |
|---|---|---|---|
| 1 | GND | G | Ground |
| 2 | RST | I | CHIP_PU, Reset |
| 3 | IO46 | I | GPIO46 |
| 4 | IO45 | I/O | GPIO45 |
| 5 | IO44 | I/O | GPIO44, U0RXD |
| 6 | IO43 | I/O | GPIO43, U0TXD |
| 7 | IO42 | I/O | GPIO42, MTMS |
| 8 | IO41 | I/O | GPIO41, MTDI |
| 9 | IO40 | I/O | GPIO40, MTDO |
| 10 | IO39 | I/O | GPIO39, MTCK |
| 11 | IO38 | I/O | GPIO38 |
| 12 | IO37 | I/O | GPIO37 |
| 13 | IO36 | I/O | GPIO36 |
| 14 | IO35 | I/O | GPIO35 |
| 16 | IO34 | I/O | GPIO34 |
| 17 | IO33 | I/O | GPIO33 |
| 17 | IO26 | I/O | GPIO26 |
| 18 | IO21 | I/O | GPIO21 |
| 19 | IO20 | I/O | GPIO20, ADC2_CH9, USB_D+ |
| 20 | IO19 | I/O | GPIO19, ADC2_CH8, USB_D- |
| 21 | IO18 | I/O | GPIO18, ADC2_CH7, DAC_2, RGB LED |

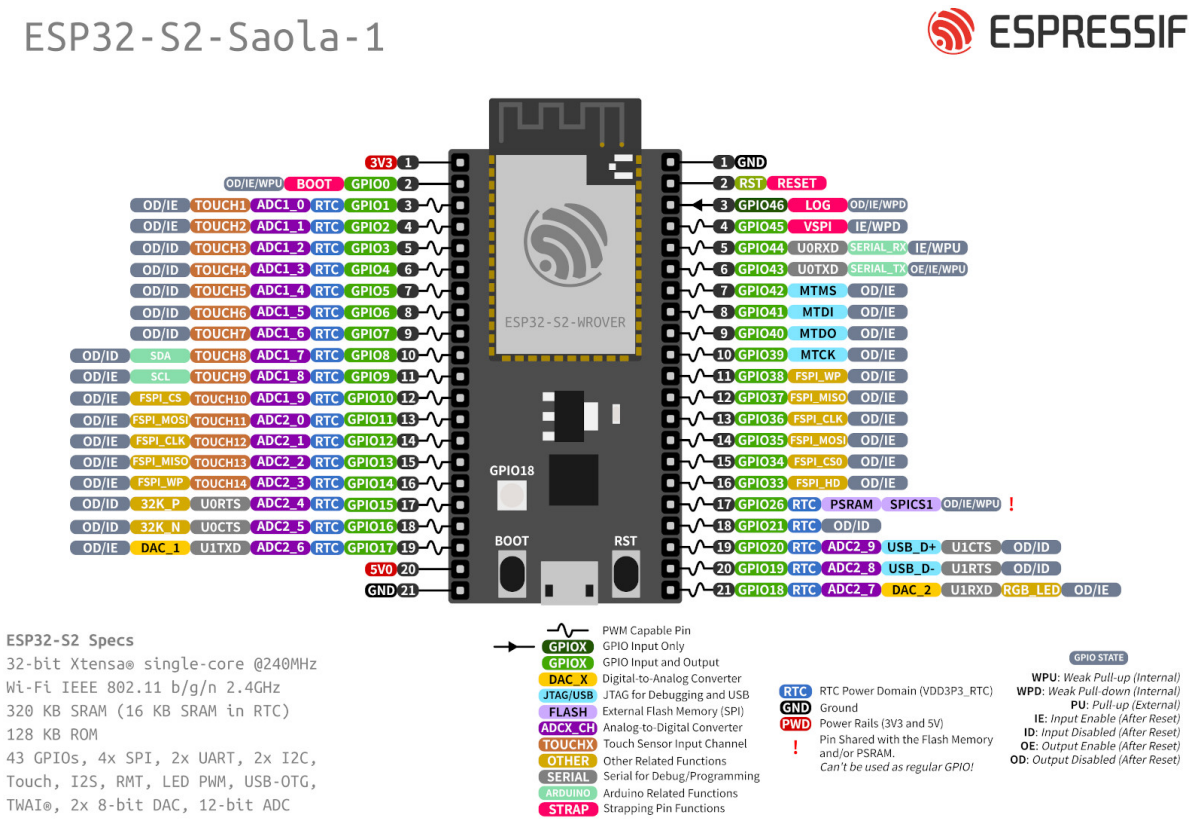



Fig. 4: ESP32-S2 Saola-1 Pin Layout (click to enlarge)

## Pin Layout

### 6.1.3 Hardware Revision Details

This is the first revision of this board released.

### 6.1.4 Related Documents

- ESP32-S2-Saola-1 Schematics (PDF)
- ESP32-S2-Saola-1 Dimensions (PDF)
- ESP32-S2 Datasheet (PDF)
- ESP32-S2-WROVER and ESP32-S2-WROVER-I Datasheet (PDF)
- ESP32-S2-WROOM and ESP32-S2-WROOM-I Datasheet (PDF)
- ESP Product Selector

For other design documentation for the board, please contact us at sales@espressif.com.

# Chapter 7

# Related Documentation and Resources

## 7.1 Related Documentation

- ESP32-S2 Datasheet –Specifications of the ESP32-S2 hardware.
- ESP32-S2 Technical Reference Manual –Detailed information on how to use the ESP32-S2 memory and peripherals.
- ESP32-S2 Hardware Design Guidelines –Guidelines on how to integrate the ESP32-S2 into your hardware product.
- ESP32-S2 Product/Process Change Notifications (PCN)
  https://espressif.com/en/support/documents/pcns?keys=ESP32-S2
- ESP32-S2 Advisories –Information on security, bugs, compatibility, component reliability.
  https://espressif.com/en/support/documents/advisories?keys=ESP32-S2
- Certificates
  https://espressif.com/en/support/documents/certificates
- Documentation Updates and Update Notification Subscription
  https://espressif.com/en/support/download/documents

## 7.2 Developer Zone

- ESP-IDF Programming Guide for ESP32-S2 –Extensive documentation for the ESP-IDF development framework.
- ESP-IoT-Solution Programming Guide - Extensive documentation for the ESP-IoT-Solution development framework.
- ESP-FAQ - A summary document of frequently asked questions released by Espressif.
- ESP-IDF and other development frameworks on GitHub.
  https://github.com/espressif
- ESP32 BBS Forum –Engineer-to-Engineer (E2E) Community for Espressif products where you can post questions, share knowledge, explore ideas, and help solve problems with fellow engineers.
  https://esp32.com/
- The ESP Journal –Best Practices, Articles, and Notes from Espressif folks.
  https://blog.espressif.com/
- See the tabs SDKs and Demos, Apps, Tools, AT Firmware.
  https://espressif.com/en/support/download/sdks-demos

## 7.3 Products

- ESP32-S2 Series SoCs –Browse through all ESP32-S2 SoCs.
  https://espressif.com/en/products/socs?id=ESP32-S2
- ESP32-S2 Series Modules –Browse through all ESP32-S2-based modules.
  https://espressif.com/en/products/modules?id=ESP32-S2
- ESP32-S2 Series DevKits –Browse through all ESP32-S2-based devkits.
  https://espressif.com/en/products/devkits?id=ESP32-S2
- ESP Product Selector –Find an Espressif hardware product suitable for your needs by comparing or applying filters.
  https://products.espressif.com/#/product-selector

## 7.4 Contact Us

- See the tabs Sales Questions, Technical Enquiries, Circuit Schematic & PCB Design Review, Get Samples (Online stores), Become Our Supplier, Comments & Suggestions.
  https://espressif.com/en/contact-us/sales-questions

# Chapter 8

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