# Read the Docs Template Documentation

**Read the Docs**

**Sep 11, 2024**

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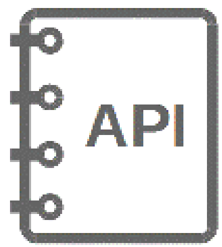
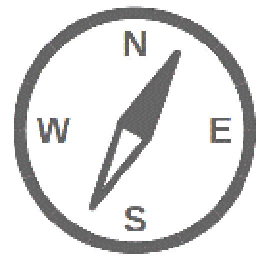
This is the documentation for Espressif Audio Development Framework (ADF).

|  |  |  |
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CHAPTER

ONE

# GET STARTED

This document is intended to help users set up the software environment for the development of audio applications using hardware based on the ESP32 family of chips by Espressif. After that, a simple example will show you how to use ESP-ADF (Espressif Audio Development Framework).

## 1.1 Development Board Overview

For easier start with ESP-ADF, Espressif designed ESP32, ESP32-S2, and ESP32-S3 based development boards intended for audio applications. Click the links below to learn more about the available boards.

- *ESP32-LyraT*
- *ESP32-LyraT-Mini*
- *ESP32-LyraTD-MSC*
- ESP32-S2-Kaluga-1
- *ESP32-Korvo-DU1906*
- *ESP32-S3-Korvo-2*
- *ESP32-C3-Lyra*

If you do not have any of the above boards, you can still use ESP-ADF for the ESP32 and ESP32-S2 based audio applications. For this, your board needs to have a compatible audio codec or DSP chip; alternatively, you can develop a driver to support communication with your specific chip.

## 1.2 About ESP-ADF

The ESP-ADF is available as a set of components to extend the functionality already delivered by the ESP-IDF (Espressif IoT Development Framework).

To use ESP-ADF you need set up the ESP-IDF first, and this is described in the next section.

**Note:** ESP-ADF provides support for specific ESP-IDF versions. If your have already set up another version, please switch to a supported ESP-IDF version, or you may not be able to compile ESP-ADF applications. In addition, the python version needs to be between 3.7 and 3.11.

## 1.3 Quick Start

This section provides quick steps to run a simple ADF sample project on an ESP device for experienced users. For beginners, please go through the complete steps from *Step 1. Set up ESP-IDF* to *Step 9. Monitor* to build a project.

**Note:** If you encounter issues in the following steps, you could refer to the complete steps from *Step 1. Set up ESP-IDF* to *Step 9. Monitor* or describe them in GitHub Issues or ESP Forum.

### 1.3.1 Linux and macOS

The operating environment below is on Linux Ubuntu 18.04 and above.

1. Download the full ESP-ADF repository from GitHub by running:

```
git clone --recursive https://github.com/espressif/esp-adf.git
```

   For users located in China, it is faster to download from Gitee:

```
git clone --recursive https://gitee.com/EspressifSystems/esp-adf.git
```

2. Configure the `$ESP-IDF` and `$ESP-ADF` compilation environment by running:

```
cd esp-adf
./install.sh
. ./export.sh
```

3. After completing the above environment variable configuration, you can compile the ADF sample project `$ADF_PATH/examples/get-started/play_mp3_control`. Switch to the project's directory, compile, and flash it onto your ESP device by running the following command. Then, you will see the serial port of the routine is printed.

```
cd $ADF_PATH/examples/get-started/play_mp3_control
idf.py build flash monitor
```

### 1.3.2 Windows

1. Download the full ESP-ADF repository from GitHub by running:

```
git clone --recursive https://github.com/espressif/esp-adf.git
```

   For users located in China, it is faster to download from Gitee:

```
git clone --recursive https://gitee.com/EspressifSystems/esp-adf.git
```

2. Install the `$ESP-IDF` compilation environment in the command prompt window:

```
cd esp-adf
.\install.bat
```

   Or first download the full ESP-IDF Windows Installer from ESP-IDF Windows Installer (Please download the ESP-IDF versions supported by ESP-ADF). And then turn off the antivirus software (Because it may prevent the installation as the software writes the Windows system regedit) and install the downloaded file. After the installation is complete, open the ESP-IDF CMD shortcut icon on the desktop, the script will automatically help you download submodules, and set environment variables such as `IDF_PATH`.

3. Set the `ADF_PATH` by running the following commands:

```
.\export.bat
echo %ADF_PATH%
```

4. If your `ADF_PATH` variable prints correctly, it's time to compile the ADF routines:

```
cd %ADF_PATH%\examples\get-started\play_mp3_control
idf.py build flash monitor
```

## 1.4 Installation Step by Step

This is a detailed roadmap to walk you through the installation process.

### 1.4.1 Setting up Development Environment

- *Step 1. Set up ESP-IDF* for Windows, Linux or Mac OS
- *Step 2. Get ESP-ADF*
- *Step 3. Set up the environment*

### 1.4.2 Creating Your First Project

- *Step 4. Start a Project*
- *Step 5. Connect Your Device*
- *Step 6. Configure*
- *Step 7. Build the Project*
- *Step 8. Flash onto the Device*
- *Step 9. Monitor*

## 1.5 Step 1. Set up ESP-IDF

Configure your PC according to **Getting Started** section of **ESP-IDF Programming Guide**. Windows, Linux and Mac OS operating systems are supported. Please select and follow the guide specific to ESP32 or ESP32-S2 chip. The chip name is provided in the board name.

**Note:** This guide uses the directory `~/esp` on Linux and macOS or `%userprofile%\esp` on Windows as an installation folder for ESP-ADF. You can use any directory, but you will need to adjust paths for the commands accordingly. Keep in mind that ESP-ADF does not support spaces in paths.

To make the installation easier and less prone to errors, use the `~/esp` default directory for the installation.

If this is your first exposure to the ESP-IDF, then it is recommended to get familiar with **hello_world** or **blink** example first.

After getting familiar with ESP-IDF, decide on which ESP-IDF version to use for your application depending on the Espressif chip that you have and your project type. For this, consult Versions section of ESP-IDF Programming Guide.

Once you successfully build, upload, and run examples for your version of ESP-IDF, you can proceed to the next step.

## 1.6 Step 2. Get ESP-ADF

Now you can start installing audio-specific API / libraries provided in ESP-ADF repository.

### 1.6.1 Windows

Open Command Prompt and run the following commands:

```
cd %userprofile%\esp
git clone --recursive https://github.com/espressif/esp-adf.git
```

### 1.6.2 Linux and macOS

Open Terminal, and run the following commands:

```
cd ~/esp
git clone --recursive https://github.com/espressif/esp-adf.git
```

## 1.7 Step 3. Set up the environment

Before being able to compile ESP-ADF projects, on each new session, ESP-IDF tools should be added to the PATH environment variable. To make the tools usable from the command line, some environment variables must be set. ESP-ADF provides a script which does that.

### 1.7.1 Windows

ESP-IDF Tools Installer for Windows creates an "ESP-IDF Command Prompt" shortcut in the Start Menu. This shortcut opens the Command Prompt and sets up all the required environment variables. You can open this shortcut and proceed to the next step.

Alternatively, if you want to use ESP-IDF in an existing Command Prompt window, you can run:

```
%userprofile%\esp\esp-adf\export.bat
```

### 1.7.2 Linux and macOS

In the terminal where you have installed ESP-IDF, run:

```
. $HOME/esp/esp-adf/export.sh
```

Note the space between the leading dot and the path!

You can also create an alias for the export script to your `.profile` or `.bash_profile` script. This way you can set up the environment in a new terminal window by typing `get_idf`:

```
alias get_idf='. $HOME/esp/esp-adf/export.sh'
```

Note that it is not recommended to source `export.sh` from the profile script directly. Doing so activates IDF virtual environment in every terminal session (even in those where IDF is not needed), defeating the purpose of the virtual environment and likely affecting other software.

## 1.8 Step 4. Start a Project

After initial preparation you are ready to build the first audio application. The process has already been described in ESP-IDF documentation. Now we would like to discuss remaining key steps and show how the toolchain is able to access the ESP-ADF components by using the `ADF_PATH` variable.

To demonstrate how to build an application, we will use get-started/play_mp3_control project from examples directory in the ADF.

### 1.8.1 Windows

```
cd %userprofile%\esp
xcopy /e /i %ADF_PATH%\examples\get-started\play_mp3_control play_mp3_control
```

### 1.8.2 Linux and macOS

```
cd ~/esp
cp -r $ADF_PATH/examples/get-started/play_mp3_control .
```

There is a range of example projects in the examples directory in ESP-ADF. You can copy any project in the same way as presented above and run it.

It is also possible to build examples in-place, without copying them first.

**Important:** The ESP-IDF build system does not support spaces in the paths to either ESP-IDF or to projects.

## 1.9 Step 5. Connect Your Device

Connect the audio board to the PC, check under what serial port the board is visible and verify, if serial communication works as described in ESP-IDF documentation.

**Note:** Keep the port name handy as you will need it in the next steps.

## 1.10 Step 6. Configure

Navigate to your `play_mp3_control` directory from *Step 4. Start a Project* and configure the project:

### 1.10.1 Windows

```
cd %userprofile%\esp\play_mp3_control
idf.py set-target esp32
idf.py menuconfig
```

### 1.10.2 Linux and macOS

```
cd ~/esp/play_mp3_control
idf.py set-target esp32
idf.py menuconfig
```

**Note:** If you are using an ESP32-S2 based board, then the second command above should be `idf.py set-target esp32s2`.

Setting the target with `idf.py set-target <target>` should be done once, after opening a new project. If the project contains some existing builds and configuration, they will be cleared and initialized. The target may be saved in environment variable to skip this step at all. See Selecting the Target in ESP-IDF Programming Guide for additional information.

If the previous steps have been done correctly, the following menu appears:

You are using this menu to set up your board type and other project specific variables, e.g. Wi-Fi network name and password, the processor speed, etc.

Select your board from the menu, press `S` to save configuration and then `Q` to exit.

**Note:** The colors of the menu could be different in your terminal. You can change the appearance with the option `--style`. Please run `idf.py menuconfig --help` for further information.

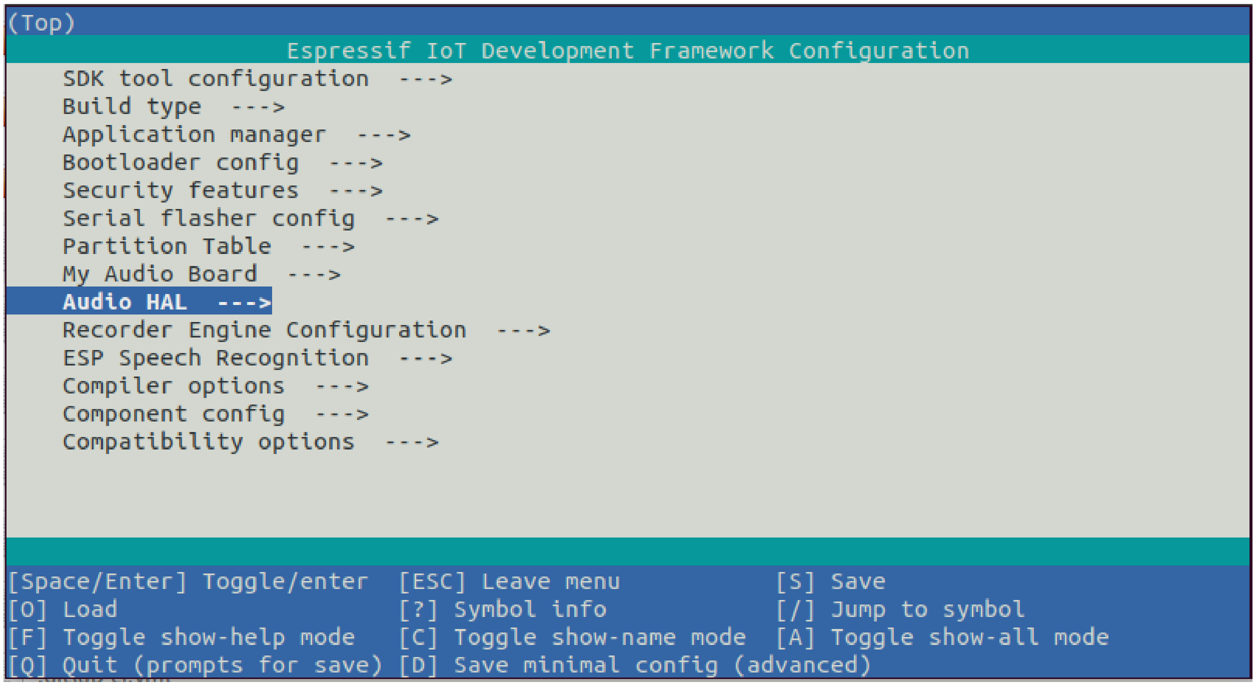


Fig. 1: Project configuration - Home window

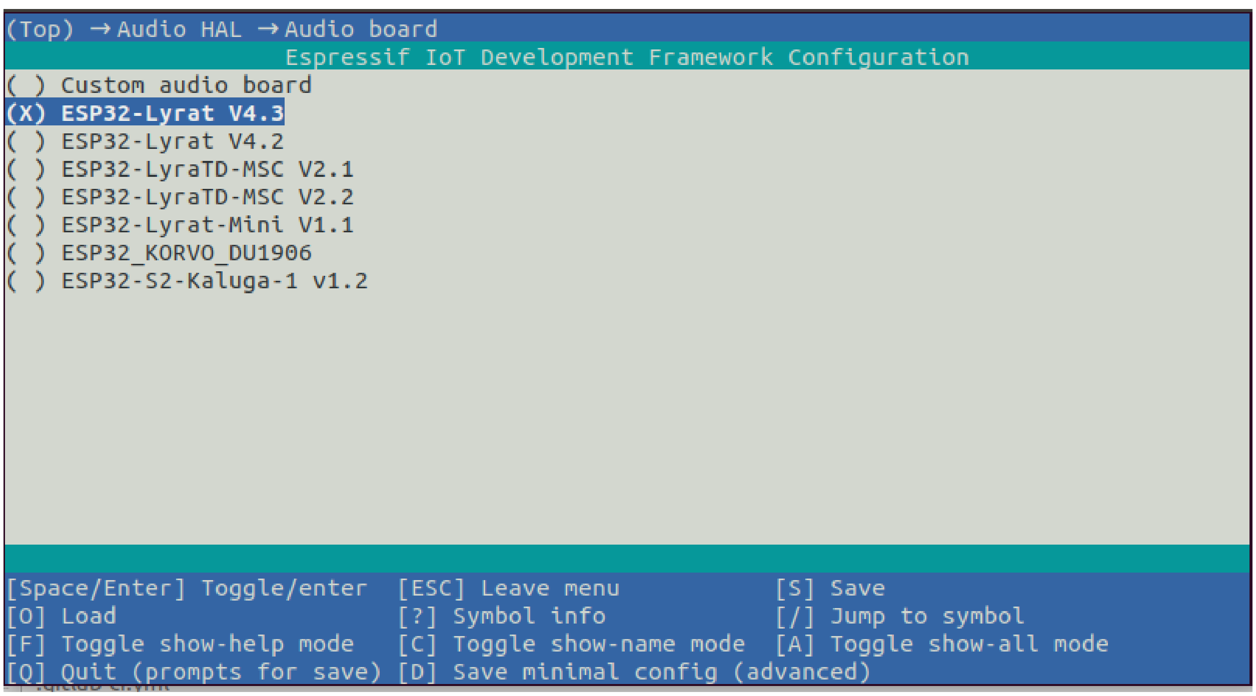


Fig. 2: Project configuration - Board selection

## 1.11 Step 7. Build the Project

Build the project by running:

```
idf.py build
```

This command will compile the application and all ESP-IDF and ESP-ADF components, then it will generate the bootloader, partition table, and application binaries.

```
$ idf.py build
 Executing action: all (aliases: build)
 Running ninja in directory /path/to/esp/play_mp3_control/build
 Executing "ninja all"...
 [0/1] Re-running CMake...

... (more lines of build system output)

 [1064/1064] Generating binary image from built executable
 esptool.py v3.0-dev
 Generated /path/to/esp/play_mp3_control/build/play_mp3_control.bin

 Project build complete. To flash it, run this command:
 /path/to/.espressif/python_env/idf4.2_py2.7_env/bin/python ../esp-idf/components/
↪esptool_py/esptool/esptool.py -p (PORT) -b 460800 --before default_reset --after␣
↪hard_reset --chip esp32  write_flash --flash_mode dio --flash_size detect --flash_
↪freq 40m 0x1000 build/bootloader/bootloader.bin 0x8000 build/partition_table/
↪partition-table.bin 0x10000 build/play_mp3_control.bin
 or run 'idf.py -p (PORT) flash'
```

If there are no errors, the build will finish by generating the firmware binary .bin file.

## 1.12 Step 8. Flash onto the Device

Flash the binaries that you just built onto your board by running:

```
idf.py -p PORT [-b BAUD] flash monitor
```

Replace PORT with your board's serial port name from *Step 5. Connect Your Device*.

You can also change the flasher baud rate by replacing BAUD with the baud rate you need. The default baud rate is `460800`.

For more information on idf.py arguments, see Using the Build System in ESP-IDF Programming Guide.

**Note:** The option `flash` automatically builds and flashes the project, so running `idf.py build` is not necessary.

To upload the binaries, the board should be put into upload mode. To do so, hold down **Boot** button, momentarily press **Reset** button and release the **Boot** button. The upload mode may be initiated anytime during the application build, but no later than "Connecting" message is being displayed:

```
...

esptool.py v3.0-dev
```

(continues on next page)

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```
Serial port /dev/ttyUSB0
Connecting........_____....
```

Without the upload mode enabled, after showing several `.....______`, the connection will eventually time out.

Once build and upload is complete, you should see the following:

```
...

Leaving...
Hard resetting via RTS pin...
Executing action: monitor
Running idf_monitor in directory /path/to/esp/play_mp3_control
Executing "/path/to/.espressif/python_env/idf4.2_py2.7_env/bin/python /path/to/esp/
↪esp-idf/tools/idf_monitor.py -p /dev/ttyUSB0 -b 115200 --toolchain-prefix xtensa-
↪esp32-elf- /path/to/esp/play_mp3_control/build/play_mp3_control.elf -m '/path/to/.
↪espressif/python_env/idf4.2_py2.7_env/bin/python' '/path/to/esp/esp-idf/tools/idf.py
↪'"...
--- idf_monitor on /dev/ttyUSB0 115200 ---
--- Quit: Ctrl+] | Menu: Ctrl+T | Help: Ctrl+T followed by Ctrl+H ---
```

If there are no issues by the end of the flash process, the board will reboot and start up the "play_mp3_control" application.

## 1.13 Step 9. Monitor

At this point press the **Reset** button to start the application. Following several lines of start up log, the `play_mp3_control` application specific messages should be displayed:

```
...

I (397) PLAY_FLASH_MP3_CONTROL: [ 1 ] Start audio codec chip
I (427) PLAY_FLASH_MP3_CONTROL: [ 2 ] Create audio pipeline, add all elements to␣
↪pipeline, and subscribe pipeline event
I (427) PLAY_FLASH_MP3_CONTROL: [2.1] Create mp3 decoder to decode mp3 file and set␣
↪custom read callback
I (437) PLAY_FLASH_MP3_CONTROL: [2.2] Create i2s stream to write data to codec chip
I (467) PLAY_FLASH_MP3_CONTROL: [2.3] Register all elements to audio pipeline
I (467) PLAY_FLASH_MP3_CONTROL: [2.4] Link it together [mp3_music_read_cb]-->mp3_
↪decoder-->i2s_stream-->[codec_chip]
I (477) PLAY_FLASH_MP3_CONTROL: [ 3 ] Set up  event listener
I (477) PLAY_FLASH_MP3_CONTROL: [3.1] Listening event from all elements of pipeline
I (487) PLAY_FLASH_MP3_CONTROL: [ 4 ] Start audio_pipeline
I (507) PLAY_FLASH_MP3_CONTROL: [ * ] Receive music info from mp3 decoder, sample_
↪rates=44100, bits=16, ch=2
I (7277) PLAY_FLASH_MP3_CONTROL: [ 5 ] Stop audio_pipeline
```

If there are no issues, besides the above log, you should hear a sound played for about 7 seconds by the speakers or headphones connected to your audio board. Reset the board to hear it again if required.

Now you are ready to try some other examples, or go right to developing your own applications. Check how the examples are made aware of location of the ESP-ADF. Open the get-started/play_mp3_control/Makefile and you should see

```
include($ENV{ADF_PATH}/CMakeLists.txt)
include($ENV{IDF_PATH}/tools/cmake/project.cmake)
```

The first line contains `ADF_PATH` to point the toolchain to another file in ESP-ADF directory that provides configuration variables and path to ESP-ADF components reacquired by the toolchain. You need similar `Makefile` in your own applications developed with the ESP-ADF.

## 1.14 VS Code Extension

1. Follow VS Code Extension Quick Installation Guide to install ESP-IDF Visual Studio Code Extension. If the previous steps have been done correctly, the following toolbar appears:

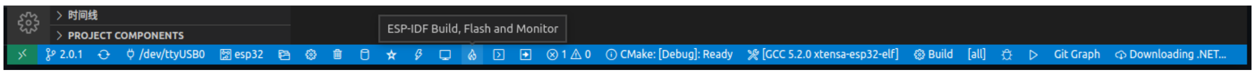


Fig. 3: VS Code Extension Toolbar

2. To install the ESP-ADF extension, open `Command Palette` and enter `install adf`. Then, a progress bar shows up in the lower right corner.

   If you have cloned the ESP-ADF repository before, please enter `open settings(ui)` in `Command Palette`. Go to `User > Extensions > ESP_IDF` and manually set the ESP-ADF path in `idf.espAdfPath` or `idf.espAdfPathWin` (for Windows). You can also set the ESP-ADF path in `.vscode/settings.json`.

3. In `Command Palette`, enter `show examples project`, and then a window will be opened with a list of example projects.

4. Select an example, click `Create project using example XX`, and select the directory to save the current example.

5. On the toolbar at the bottom of VS Code, click the gear symbol `menuconfig` to configure the example and click the column symbol `Build` to build the example. See available shortcut keys for VS code extensions.

6. On the toolbar at the bottom of VS Code, click the plug-in symbol `Select Port` to configure the serial port and click the lightning symbol `Flash Device` to flash firmware. After the firmware is flashed successfully, click `Monitor Device` to start the monitor function. Or, you can also use the flame symbol to build, flash, and monitor the example at the same time.

## 1.15 IDF Eclipse Plugin and Espressif IDE

### 1.15.1 Install and Set up Environment Variables

1. Follow IDF Eclipse Plugin Quick Installation Guide to install IDF Eclipse Plugin or download and install Espressif IDE from Espressif IDE Download Link. If the previous steps have been done correctly, you can create, build and flash IDF project in the Eclipse environment.

2. To install ESP-ADF, follow section *Step 2. Get ESP-ADF*.

3. To set `ADF_PATH` environment variable, open `Window > Preferences > C/C++ > Build > Environment` panel, click **Add** button and fill in `ADF_PATH`. After you complete the above steps, select `ADF_PATH` in `Environment variables` table and click **Edit** and **OK** button without changing any value (There is a bug in Eclipse CDT that is appending a null value before the path hence we need to click on edit and save it.).

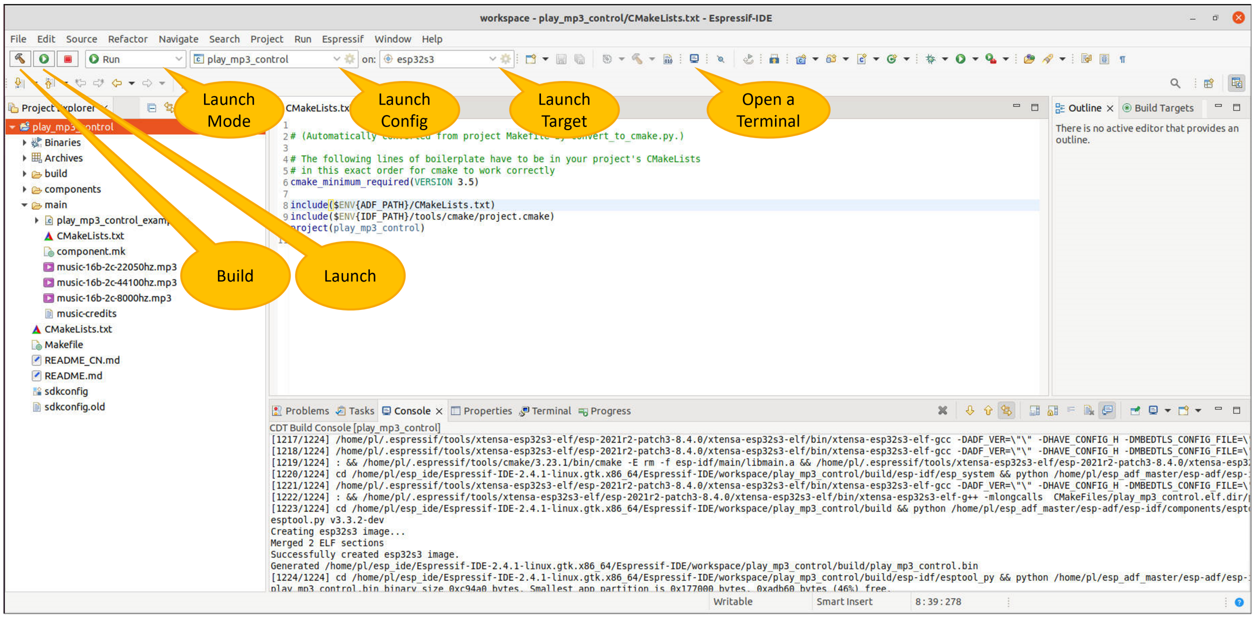


Fig. 4: Espressif IDE (Reskinned Eclipse)

If this step does not work, you can delete `ADF_PATH` set in Eclipse and set `ADF_PATH` as system environment variable. For Windows, set environment variable in `Advanced System Setting` panel. For Linux and macOS, add `export ADF_PATH=your adf path` in file `/etc/profile`. However, it is not recommended. Doing so activates ADF virtual environment in every terminal session (including those where ADF is not needed), defeating the purpose of the virtual environment and likely affecting other software.

### 1.15.2 Create a New Project

1. To create new project, go to `File` > `New` > `Espressif IDF Project` and provide a project name.
2. Click **Finish** to create an empty project. Or click **Next** and check `Create a project using one of the templates` to create a project using ESP-IDF templates.

After creating a new project, you can use ESP-IDF and ESP-ADF to develop the project.

### 1.15.3 Import Existing Project

To import existing ESP-ADF examples, go to `File` > `Import` > `Espressif` > `Existing IDF Project` and select an ESP-ADF example (Opening an existing project directly may not be able to set the ESP target).

### 1.15.4 Quick Start

1. Select a project from `Project Explorer`.
2. In the **Launch Mode** drop-down menu, select `Run`.
3. In the **Launch Configuration** (auto-detected) drop-down menu, select your application.
4. Select ESP target from the third drop-down, which is called **Launch Target**. Click gear symbol **Edit** button of **Launch Target** to set `Serial Port`.
5. Double click `sdkconfig` file to launch the `SDK Configuration Editor`.
6. Click **Build** button to build the project.
7. Click **Launch** button to flash the project.
8. Click **Open a Terminal** button and select **ESP-IDF Serial Monitor** to view serial output.

For more information about IDF Eclipse Plugin and Espressif IDE, please refer to ESP-IDF Eclipse Plugin.

## 1.16 Update ESP-ADF

After some time of using ESP-ADF, you may want to update it to take advantage of new features or bug fixes. The simplest way to do so is by deleting existing `esp-adf` folder and cloning it again, which is same as when doing initial installation described in sections *Step 2. Get ESP-ADF*.

Another solution is to update only what has changed. This method is useful if you have a slow connection to the GitHub. To do the update run the following commands:

```
cd ~/esp/esp-adf
git pull
git submodule update --init --recursive
```

The `git pull` command is fetching and merging changes from ESP-ADF repository on GitHub. Then `git submodule update --init --recursive` is updating existing submodules or getting a fresh copy of new ones. On GitHub the submodules are represented as links to other repositories and require this additional command to get them onto your PC.

CHAPTER

# TWO

# API REFERENCE

This API provides a way to develop audio applications using *Elements* like *Codecs* (Decoders and Encoders), *Streams* or *Audio Processing* functions.

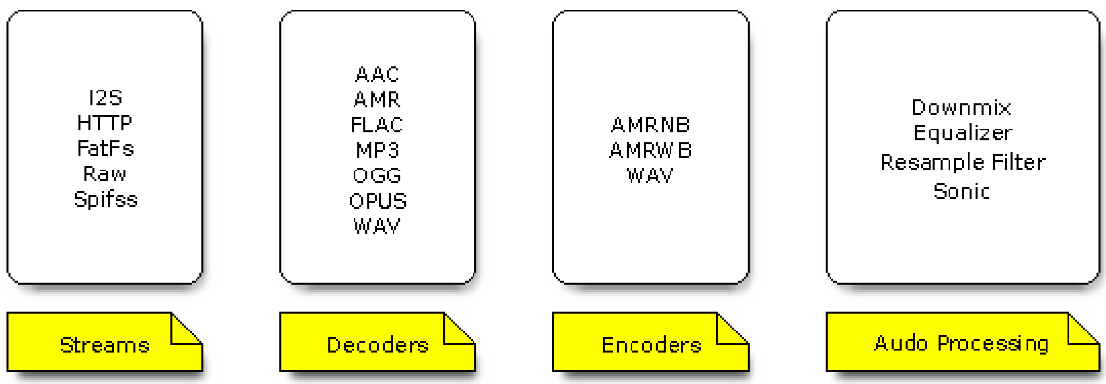


Fig. 1: **Elements** of the Audio Development Framework

The application is developed by combining the *Elements* into a *Pipeline*. A diagram below presents organization of two elements, MP3 decoder and I2S stream, in the Audio Pipeline, that has been used in get-started/play_mp3_control example.

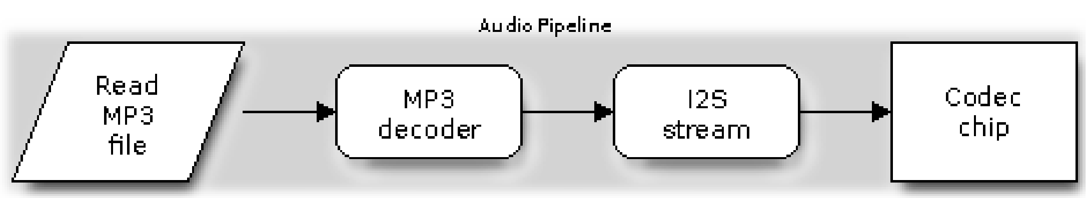


Fig. 2: Sample Organization of Elements in Audio Pipeline

The audio data is typically acquired using an input *Stream*, processed with *Codecs* and in some cases with *Audio Processing* functions, and finally output with another *Stream*. There is an *Event Interface* to facilitate communication of the application events. Interfacing with specific hardware is done using *Peripherals*.

See a table of contents below with links to description of all the above components.

## 2.1 Audio Framework

### 2.1.1 Audio Element

The basic building block for the application programmer developing with ADF is the `audio_element` object. Every decoder, encoder, filter, input stream, or output stream is in fact an Audio Element.

This API has been designed and then used to implement Audio Elements provided by ADF.

The general functionality of an Element is to take some data on input, processes it, and output to the next. Each Element is run as a separate task. To enable control on particular stages of the data lifecycle from the input, during processing and up to the output, the `audio_element` object provides possibility to trigger callbacks per stage. There are seven types of available callback functions: open, seek, process, close, destroy, read and write, and they are defined in `audio_element_cfg_t`. Particular Elements typically use a subset of all available callbacks. For instance the *MP3 Decoder* is using open, process, close and destroy callback functions.

The available Audio Element types intended for development with this API are listed in description of *audio_common.h* header file under `audio_element_type_t` enumerator.

#### API Reference

#### Header File

- audio_pipeline/include/audio_element.h

#### Functions

*audio_element_handle_t* **audio_element_init** (*audio_element_cfg_t *config*)

Initialize audio element with config.

**Return**

- audio_elemenent handle object
- NULL

**Parameters**

- `config`: The configuration

esp_err_t **audio_element_deinit** (*audio_element_handle_t el*)

Destroy audio element handle object, stop, clear, deletel all.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_setdata** (*audio_element_handle_t el*, void **data*)

Set context data to element handle object. It can be retrieved by calling `audio_element_getdata`.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `data`: The data pointer

void ***`audio_element_getdata`**(*audio_element_handle_t el*)

Get context data from element handle object.

**Return** data pointer

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **`audio_element_set_tag`**(*audio_element_handle_t el*, **const** char **tag*)

Set elemenet tag name, or clear if tag = NULL.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] tag`: The tag name pointer

char ***`audio_element_get_tag`**(*audio_element_handle_t el*)

Get element tag name.

**Return** Element tag name pointer

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **`audio_element_setinfo`**(*audio_element_handle_t el*, *audio_element_info_t* **info*)

Set audio element infomation.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `info`: The information pointer

esp_err_t **`audio_element_getinfo`**(*audio_element_handle_t el*, *audio_element_info_t* **info*)

Get audio element infomation.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `info`: The information pointer

esp_err_t **audio_element_set_uri** (*audio_element_handle_t el*, **const** char **uri*)

Set audio element URI.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] uri`: The uri pointer

char ***audio_element_get_uri** (*audio_element_handle_t el*)

Get audio element URI.

**Return** URI pointer

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_run** (*audio_element_handle_t el*)

Start Audio Element. With this function, audio_element will start as freeRTOS task, and put the task into 'PAUSED' state. Note: Element does not actually start when this function returns.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_terminate** (*audio_element_handle_t el*)

Terminate Audio Element. With this function, audio_element will exit the task function. Note: this API only sends request. It does not actually terminate immediately when this function returns.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_terminate_with_ticks**(*audio_element_handle_t el*, TickType_t *ticks_to_wait*)

Terminate Audio Element with specific ticks for timeout. With this function, audio_element will exit the task function. Note: this API only sends request. It does not actually terminate immediately when this function returns.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] ticks_to_wait`: The maximum amount of time to blocking

esp_err_t **audio_element_stop**(*audio_element_handle_t el*)

Request stop of the Audio Element. After receiving the stop request, the element will ignore the actions being performed (read/write, wait for the ringbuffer …) and close the task, reset the state variables. Note: this API only sends requests, Element does not actually stop when this function returns.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_wait_for_stop**(*audio_element_handle_t el*)

After the `audio_element_stop` function is called, the Element task will perform some abort procedures. This function will be blocked (Time is DEFAULT_MAX_WAIT_TIME) until Element Task has done and exit.

**Return**

- ESP_OK, Success
- ESP_FAIL, The state is not AEL_STATE_RUNNING
- ESP_ERR_TIMEOUT, Timeout

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_wait_for_stop_ms**(*audio_element_handle_t el*, TickType_t *ticks_to_wait*)

After the `audio_element_stop` function is called, the Element task will perform some abort procedures. The maximum amount of time should block waiting for Element task has stopped.

**Return**

- ESP_OK, Success
- ESP_FAIL, The state is not AEL_STATE_RUNNING
- ESP_ERR_TIMEOUT, Timeout

**Parameters**

- `[in] el`: The audio element handle
- `[in] ticks_to_wait`: The maximum amount of time to wait for stop

esp_err_t **audio_element_pause**(*audio_element_handle_t el*)

Request audio Element enter 'PAUSE' state. In this state, the task will wait for any event.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_resume**(*audio_element_handle_t el*, float *wait_for_rb_threshold*, TickType_t *timeout*)

Request audio Element enter 'RUNNING' state. In this state, the task listens to events and invokes the callback functions. At the same time it will wait until the size/total_size of the output ringbuffer is greater than or equal to `wait_for_rb_threshold`. If the timeout period has been exceeded and ringbuffer output has not yet reached `wait_for_rb_threshold` then the function will return.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] wait_for_rb_threshold`: The wait for rb threshold (0 .. 1)
- `[in] timeout`: The timeout

esp_err_t **audio_element_msg_set_listener**(*audio_element_handle_t el*, *audio_event_iface_handle_t listener*)

This function will add a `listener` to listen to all events from audio element `el`. Any event from el->external_event will be send to the `listener`.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `el`: The audio element handle
- `listener`: The event will be listen to

esp_err_t **audio_element_set_event_callback**(*audio_element_handle_t el*, *event_cb_func cb_func*, void **ctx*)

This function will add a `callback` to be called from audio element `el`. Any event to caller will cause to call callback function.

**Return**

- ESP_OK

- ESP_FAIL

**Parameters**

- `el`: The audio element handle
- `cb_func`: The callback function
- `ctx`: Caller context

esp_err_t **audio_element_msg_remove_listener** (*audio_element_handle_t el*, *audio_event_iface_handle_t listener*)

Remove listener out of el. No new events will be sent to the listener.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `listener`: The listener

esp_err_t **audio_element_set_input_ringbuf** (*audio_element_handle_t el*, *ringbuf_handle_t rb*)

Set Element input ringbuffer.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] rb`: The ringbuffer handle

*ringbuf_handle_t* **audio_element_get_input_ringbuf** (*audio_element_handle_t el*)

Get Element input ringbuffer.

**Return** ringbuf_handle_t

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_set_output_ringbuf** (*audio_element_handle_t el*, *ringbuf_handle_t rb*)

Set Element output ringbuffer.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] rb`: The ringbuffer handle

*ringbuf_handle_t* **audio_element_get_output_ringbuf**(*audio_element_handle_t el*)
Get Element output ringbuffer.

**Return** ringbuf_handle_t

**Parameters**

- `[in] el`: The audio element handle

*audio_element_state_t* **audio_element_get_state**(*audio_element_handle_t el*)
Get current Element state.

**Return** audio_element_state_t

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_abort_input_ringbuf**(*audio_element_handle_t el*)
If the element is requesting data from the input ringbuffer, this function forces it to abort.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_abort_output_ringbuf**(*audio_element_handle_t el*)
If the element is waiting to write data to the ringbuffer output, this function forces it to abort.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_wait_for_buffer**(*audio_element_handle_t el*, int *size_expect*, TickType_t *timeout*)
This function will wait until the sizeof the output ringbuffer is greater than or equal to `size_expect`. If the timeout period has been exceeded and ringbuffer output has not yet reached `size_expect` then the function will return `ESP_FAIL`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] size_expect`: The size expect
- `[in] timeout`: The timeout

esp_err_t **audio_element_report_status** (*audio_element_handle_t el*, *audio_element_status_t status*)
Element will sendout event (status) to event by this function.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] status`: The status

esp_err_t **audio_element_report_info** (*audio_element_handle_t el*)
Element will sendout event (information) to event by this function.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_report_codec_fmt** (*audio_element_handle_t el*)
Element will sendout event (codec format) to event by this function.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_report_pos** (*audio_element_handle_t el*)
Element will sendout event with a duplicate information by this function.

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_NO_MEM

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_set_input_timeout** (*audio_element_handle_t el*, TickType_t *timeout*)
Set input read timeout (default is `portMAX_DELAY`).

**Return**

- ESP_OK

- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] timeout`: The timeout

esp_err_t **audio_element_set_output_timeout** (*audio_element_handle_t el*, TickType_t *timeout*)
Set output read timeout (default is `portMAX_DELAY`).

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] timeout`: The timeout

esp_err_t **audio_element_reset_input_ringbuf** (*audio_element_handle_t el*)
Reset inputbuffer.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_finish_state** (*audio_element_handle_t el*)
Set element finish state.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_change_cmd** (*audio_element_handle_t el*, *audio_element_msg_cmd_t cmd*)
Change element running state with specific command.

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG Element handle is null

**Parameters**

- `[in] el`: The audio element handle
- `[in] cmd`: Specific command from audio_element_msg_cmd_t

esp_err_t **audio_element_reset_output_ringbuf** (*audio_element_handle_t el*)
Reset outputbuffer.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

*audio_element_err_t* **audio_element_input** (*audio_element_handle_t el*, char **buffer*, int *wanted_size*)
Call this function to provide Element input data. Depending on setup using ringbuffer or function callback, Element invokes read ringbuffer, or calls read callback funtion.

**Return**

- > 0 number of bytes produced
- <=0 audio_element_err_t

**Parameters**

- `[in] el`: The audio element handle
- `buffer`: The buffer pointer
- `[in] wanted_size`: The wanted size

*audio_element_err_t* **audio_element_output** (*audio_element_handle_t el*, char **buffer*, int *write_size*)
Call this function to sendout Element output data. Depending on setup using ringbuffer or function callback, Element will invoke write to ringbuffer, or call write callback funtion.

**Return**

- > 0 number of bytes written
- <=0 audio_element_err_t

**Parameters**

- `[in] el`: The audio element handle
- `buffer`: The buffer pointer
- `[in] write_size`: The write size

esp_err_t **audio_element_set_read_cb** (*audio_element_handle_t el*, *stream_func fn*, void **context*)
This API allows the application to set a read callback for the first audio_element in the pipeline for allowing the pipeline to interface with other systems. The callback is invoked every time the audio element requires data to be processed.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

- `[in] fn`: Callback read function. The callback function should return number of bytes read or -1 in case of error in reading. Note that the callback function may decide to block and that may block the entire pipeline.
- `[in] context`: An optional context which will be passed to callback function on every invocation

esp_err_t **audio_element_set_write_cb**(*audio_element_handle_t el*, *stream_func fn*, void **context*)

This API allows the application to set a write callback for the last audio_element in the pipeline for allowing the pipeline to interface with other systems. The callback is invoked every time the audio element has a processed data that needs to be passed forward.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element
- `[in] fn`: Callback write function The callback function should return number of bytes written or -1 in case of error in writing. Note that the callback function may decide to block and that may block the entire pipeline.
- `[in] context`: An optional context which will be passed to callback function on every invocation

*stream_func* **audio_element_get_write_cb**(*audio_element_handle_t el*)

Get callback write function that register to the element.

**Return**

- Callback write function pointer
- NULL Failed

**Parameters**

- `[in] el`: The audio element

*stream_func* **audio_element_get_read_cb**(*audio_element_handle_t el*)

Get callback read function that register to the element.

**Return**

- Callback read function pointer
- NULL Failed

**Parameters**

- `[in] el`: The audio element

QueueHandle_t **audio_element_get_event_queue**(*audio_element_handle_t el*)

Get External queue of Emitter. We can read any event that has been send out of Element from this `QueueHandle_t`.

**Return** QueueHandle_t

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_set_ringbuf_done** (*audio_element_handle_t el*)
Set inputbuffer and outputbuffer have finished.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_reset_state** (*audio_element_handle_t el*)
Enforce 'AEL_STATE_INIT' state.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

int **audio_element_get_output_ringbuf_size** (*audio_element_handle_t el*)
Get Element output ringbuffer size.

**Return**

- =0: Parameter NULL
- >0: Size of ringbuffer

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_set_output_ringbuf_size** (*audio_element_handle_t el*, int *rb_size*)
Set Element output ringbuffer size.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] rb_size`: Size of the ringbuffer

int **audio_element_multi_input** (*audio_element_handle_t el*, char **buffer*, int *wanted_size*, int *index*, TickType_t *ticks_to_wait*)
Call this function to read data from multi input ringbuffer by given index.

**Return**

- ESP_ERR_INVALID_SIZE
- Others are same as the `rb_read`

**Parameters**

- `el`: The audio element handle
- `buffer`: The buffer pointer
- `wanted_size`: The wanted size
- `index`: The index of multi input ringbuffer, start from `0`, should be less than `NUMBER_OF_MULTI_RINGBUF`
- `ticks_to_wait`: Timeout of ringbuffer

int **audio_element_multi_output** (*audio_element_handle_t el*, char **buffer*, int *wanted_size*, TickType_t *ticks_to_wait*)

Call this function write data by multi output ringbuffer.

**Return**

- The return value is same as the `rb_write`

**Parameters**

- `[in] el`: The audio element handle
- `buffer`: The buffer pointer
- `[in] wanted_size`: The wanted size
- `ticks_to_wait`: Timeout of ringbuffer

esp_err_t **audio_element_set_multi_input_ringbuf** (*audio_element_handle_t el*, *ringbuf_handle_t rb*, int *index*)

Set multi input ringbuffer Element.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] rb`: The ringbuffer handle
- `[in] index`: Index of multi ringbuffer, starts from `0`, should be less than `NUMBER_OF_MULTI_RINGBUF`

esp_err_t **audio_element_set_multi_output_ringbuf** (*audio_element_handle_t el*, *ringbuf_handle_t rb*, int *index*)

Set multi output ringbuffer Element.

**Return**

- ESP_OK
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] el`: The audio element handle
- `[in] rb`: The ringbuffer handle

- `[in] index`: Index of multi ringbuffer, starts from `0`, should be less than `NUMBER_OF_MULTI_RINGBUF`

*ringbuf_handle_t* **audio_element_get_multi_input_ringbuf**(*audio_element_handle_t el*, int *index*)

Get handle of multi input ringbuffer Element by index.

**Return**

- NULL Error
- Others ringbuf_handle_t

**Parameters**

- `[in] el`: The audio element handle
- `[in] index`: Index of multi ringbuffer, starts from `0`, should be less than `NUMBER_OF_MULTI_RINGBUF`

*ringbuf_handle_t* **audio_element_get_multi_output_ringbuf**(*audio_element_handle_t el*, int *index*)

Get handle of multi output ringbuffer Element by index.

**Return**

- NULL Error
- Others ringbuf_handle_t

**Parameters**

- `[in] el`: The audio element handle
- `[in] index`: Index of multi ringbuffer, starts from `0`, should be less than `NUMBER_OF_MULTI_RINGBUF`

esp_err_t **audio_element_process_init**(*audio_element_handle_t el*)

Provides a way to call element's `open`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_process_deinit**(*audio_element_handle_t el*)

Provides a way to call element's `close`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_seek** (*audio_element_handle_t el*, void **in_data*, int *in_size*, void **out_data*, int **out_size*)

Call element's `seek`

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_NOT_SUPPORTED

**Parameters**

- `[in] el`: The audio element handle
- `[in] in_data`: A pointer to in data
- `[in] in_size`: The size of the `in_data`
- `[out] out_data`: A pointer to the out data
- `[out] out_size`: The size of the `out_data`

bool **audio_element_is_stopping** (*audio_element_handle_t el*)

Get Element stopping flag.

**Return** element's stopping flag

**Parameters**

- `[in] el`: The audio element handle

esp_err_t **audio_element_update_byte_pos** (*audio_element_handle_t el*, int *pos*)

Update the byte position of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] pos`: The byte_pos accumulated by this value

esp_err_t **audio_element_set_byte_pos** (*audio_element_handle_t el*, int *pos*)

Set the byte position of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] pos`: This value is assigned to byte_pos

esp_err_t **audio_element_update_total_bytes** (*audio_element_handle_t el*, int *total_bytes*)

Update the total bytes of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] total_bytes`: The total_bytes accumulated by this value

esp_err_t **`audio_element_set_total_bytes`** (*audio_element_handle_t el*, int *total_bytes*)

Set the total bytes of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] total_bytes`: This value is assigned to total_bytes

esp_err_t **`audio_element_set_bps`** (*audio_element_handle_t el*, int *bit_rate*)

Set the bps of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] bit_rate`: This value is assigned to bps

esp_err_t **`audio_element_set_codec_fmt`** (*audio_element_handle_t el*, int *format*)

Set the codec format of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] format`: This value is assigned to codec_fmt

esp_err_t **`audio_element_set_music_info`** (*audio_element_handle_t el*, int *sample_rates*, int *channels*, int *bits*)

Set the sample_rate, channels, bits of element information.

**Return**

- ESP_OK

- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] sample_rates`: Sample_rates of music information
- `[in] channels`: Channels of music information
- `[in] bits`: Bits of music information

esp_err_t **audio_element_set_duration** (*audio_element_handle_t el*, int *duration*)
Set the duration of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] duration`: This value is assigned to duration

esp_err_t **audio_element_set_reserve_user0** (*audio_element_handle_t el*, int *user_data0*)
Set the user_data_0 of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] user_data0`: This value is assigned to user_data_0

esp_err_t **audio_element_set_reserve_user1** (*audio_element_handle_t el*, int *user_data1*)
Set the user_data_1 of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] user_data1`: This value is assigned to user_data_1

esp_err_t **audio_element_set_reserve_user2** (*audio_element_handle_t el*, int *user_data2*)
Set the user_data_2 of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] user_data2`: This value is assigned to user_data_2

esp_err_t **audio_element_set_reserve_user3** (*audio_element_handle_t el*, int *user_data3*)
Set the user_data_3 of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] user_data3`: This value is assigned to user_data_3

esp_err_t **audio_element_set_reserve_user4** (*audio_element_handle_t el*, int *user_data4*)
Set the user_data_4 of element information.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] user_data4`: This value is assigned to user_data_4

### Structures

**struct audio_element_reserve_data_t**
Audio Element user reserved data.

#### Public Members

int **user_data_0**
user data 0

int **user_data_1**
user data 1

int **user_data_2**
user data 2

int **user_data_3**
user data 3

int **user_data_4**
user data 4

**struct audio_element_info_t**
Audio Element informations.

### Public Members

int **sample_rates**
Sample rates in Hz

int **channels**
Number of audio channel, mono is 1, stereo is 2

int **bits**
Bit wide (8, 16, 24, 32 bits)

int **bps**
Bit per second

int64_t **byte_pos**
The current position (in bytes) being processed for an element

int64_t **total_bytes**
The total bytes for an element

int **duration**
The duration for an element (optional)

char ***uri**
URI (optional)

esp_codec_type_t **codec_fmt**
Music format (optional)

*audio_element_reserve_data_t* **reserve_data**
This value is reserved for user use (optional)

**struct audio_element_cfg_t**
Audio Element configurations. Each Element at startup will be a self-running task. These tasks will execute the callback open -> [loop: read -> process -> write] -> close. These callback functions are provided by the user corresponding to this configuration.

### Public Members

*el_io_func* **open**
Open callback function

*ctrl_func* **seek**
Seek callback function

*process_func* **process**
Process callback function

*el_io_func* **close**
Close callback function

*el_io_func* **destroy**
Destroy callback function

*stream_func* **read**
Read callback function

*stream_func* **write**
Write callback function

int **buffer_len**
Buffer length use for an Element

int **task_stack**
Element task stack

int **task_prio**
Element task priority (based on freeRTOS priority)

int **task_core**
Element task running in core (0 or 1)

int **out_rb_size**
Output ringbuffer size

void ***data**
User context

**const** char ***tag**
Element tag

bool **stack_in_ext**
Try to allocate stack in external memory

int **multi_in_rb_num**
The number of multiple input ringbuffer

int **multi_out_rb_num**
The number of multiple output ringbuffer

### Macros

**AUDIO_ELEMENT_INFO_DEFAULT**()

**DEFAULT_ELEMENT_RINGBUF_SIZE**

**DEFAULT_ELEMENT_BUFFER_LENGTH**

**DEFAULT_ELEMENT_STACK_SIZE**

**DEFAULT_ELEMENT_TASK_PRIO**

**DEFAULT_ELEMENT_TASK_CORE**

**DEFAULT_AUDIO_ELEMENT_CONFIG**()

### Type Definitions

**typedef struct** audio_element ***audio_element_handle_t**

**typedef** esp_err_t (***el_io_func**) (*audio_element_handle_t* self)

**typedef** *audio_element_err_t* (***process_func**) (*audio_element_handle_t* self, char *el_buffer, int el_buf_len)

**typedef** *audio_element_err_t* (***stream_func**) (*audio_element_handle_t* self, char *buffer, int len, TickType_t ticks_to_wait, void *context)

**typedef** esp_err_t (***event_cb_func**) (*audio_element_handle_t* el, *audio_event_iface_msg_t* *event, void *ctx)

**typedef** esp_err_t (***ctrl_func**) (*audio_element_handle_t* self, void *in_data, int in_size, void *out_data, int *out_size)

### Enumerations

**enum audio_element_err_t**

*Values:*

**AEL_IO_OK** = ESP_OK

**AEL_IO_FAIL** = ESP_FAIL

**AEL_IO_DONE** = -2

**AEL_IO_ABORT** = -3

**AEL_IO_TIMEOUT** = -4

**AEL_PROCESS_FAIL** = -5

**enum audio_element_state_t**

Audio element state.

*Values:*

**AEL_STATE_NONE** = 0

**AEL_STATE_INIT** = 1

**AEL_STATE_INITIALIZING** = 2

**AEL_STATE_RUNNING** = 3

**AEL_STATE_PAUSED** = 4

**AEL_STATE_STOPPED** = 5

**AEL_STATE_FINISHED** = 6

**AEL_STATE_ERROR** = 7

**enum audio_element_msg_cmd_t**

Audio element action command, process on dispatcher

*Values:*

**AEL_MSG_CMD_NONE** = 0

**AEL_MSG_CMD_FINISH** = 2

**AEL_MSG_CMD_STOP** = 3

**AEL_MSG_CMD_PAUSE** = 4

**AEL_MSG_CMD_RESUME** = 5

**AEL_MSG_CMD_DESTROY** = 6

**AEL_MSG_CMD_REPORT_STATUS** = 8

**AEL_MSG_CMD_REPORT_MUSIC_INFO** = 9

**AEL_MSG_CMD_REPORT_CODEC_FMT** = 10

**AEL_MSG_CMD_REPORT_POSITION** = 11

**enum audio_element_status_t**

Audio element status report

*Values:*

**AEL_STATUS_NONE** = 0

**AEL_STATUS_ERROR_OPEN** = 1

**AEL_STATUS_ERROR_INPUT** = 2

**AEL_STATUS_ERROR_PROCESS** = 3

**AEL_STATUS_ERROR_OUTPUT** = 4

**AEL_STATUS_ERROR_CLOSE** = 5

**AEL_STATUS_ERROR_TIMEOUT** = 6

**AEL_STATUS_ERROR_UNKNOWN** = 7

**AEL_STATUS_INPUT_DONE** = 8

**AEL_STATUS_INPUT_BUFFERING** = 9

**AEL_STATUS_OUTPUT_DONE** = 10

**AEL_STATUS_OUTPUT_BUFFERING** = 11

**AEL_STATUS_STATE_RUNNING** = 12

**AEL_STATUS_STATE_PAUSED** = 13

**AEL_STATUS_STATE_STOPPED** = 14

**AEL_STATUS_STATE_FINISHED** = 15

**AEL_STATUS_MOUNTED** = 16

**AEL_STATUS_UNMOUNTED** = 17

### 2.1.2 Audio Pipeline

Dynamic combination of a group of linked *Elements* is done using the Audio Pipeline. You do not deal with the individual elements but with just one audio pipeline. Every element is connected by a ringbuffer. The Audio Pipeline also takes care of forwarding messages from the element tasks to an application.

A diagram below presents organization of three elements, HTTP reader stream, MP3 decoder and I2S writer stream, in the Audio Pipeline, that has been used in player/pipeline_http_mp3 example.

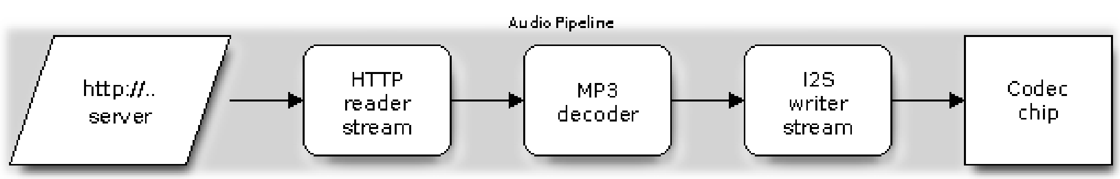


Fig. 3: Sample Organization of Elements in Audio Pipeline

### API Reference

### Header File

- audio_pipeline/include/audio_pipeline.h

### Functions

*audio_pipeline_handle_t* **audio_pipeline_init**(*audio_pipeline_cfg_t *config*)
Initialize audio_pipeline_handle_t object audio_pipeline is responsible for controlling the audio data stream and connecting the audio elements with the ringbuffer It will connect and start the audio element in order, responsible for retrieving the data from the previous element and passing it to the element after it. Also get events from each element, process events or pass it to a higher layer.

**Return**

- audio_pipeline_handle_t on success
- NULL when any errors

**Parameters**

- `config`: The configuration - audio_pipeline_cfg_t

esp_err_t **audio_pipeline_deinit**(*audio_pipeline_handle_t pipeline*)
This function removes all of the element's links in audio_pipeline, cancels the registration of all events, invokes the destroy functions of the registered elements, and frees the memory allocated by the init function. Briefly, frees all memory.

**Return** ESP_OK

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_register**(*audio_pipeline_handle_t pipeline*, *audio_element_handle_t el*, **const** char **name*)
Registering an element for audio_pipeline, each element can be registered multiple times, but `name` (as String) must be unique in audio_pipeline, which is used to identify the element for link creation mentioned in the `audio_pipeline_link`

**Note** Because of stop pipeline or pause pipeline depend much on register order. Please register element strictly in the following order: input element first, process middle, output element last.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] el`: The Audio Element Handle
- `[in] name`: The name identifier of the audio_element in this audio_pipeline

esp_err_t **audio_pipeline_unregister**(*audio_pipeline_handle_t pipeline*, *audio_element_handle_t el*)

Unregister the audio_element in audio_pipeline, remove it from the list.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] el`: The Audio Element Handle

esp_err_t **audio_pipeline_run**(*audio_pipeline_handle_t pipeline*)

Start Audio Pipeline.

```
With this function audio_pipeline will create tasks for all elements,
that have been linked using the linking functions.
```

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_terminate**(*audio_pipeline_handle_t pipeline*)

Stop Audio Pipeline.

```
With this function audio_pipeline will destroy tasks of all elements,
that have been linked using the linking functions.
```

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_terminate_with_ticks**(*audio_pipeline_handle_t pipeline*, TickType_t *ticks_to_wait*)

Stop Audio Pipeline with specific ticks for timeout.

```
With this function audio_pipeline will destroy tasks of all elements,
that have been linked using the linking functions.
```

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] ticks_to_wait`: The maximum amount of time to block wait for element destroy

esp_err_t **audio_pipeline_resume** (*audio_pipeline_handle_t pipeline*)
This function will set all the elements to the `RUNNING` state and process the audio data as an inherent feature of audio_pipeline.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_pause** (*audio_pipeline_handle_t pipeline*)
This function will set all the elements to the `PAUSED` state. Everything remains the same except the data processing is stopped.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_stop** (*audio_pipeline_handle_t pipeline*)
Stop all of the linked elements. Used with `audio_pipeline_wait_for_stop` to keep in sync. The link state of the elements in the pipeline is kept, events are still registered. The stopped audio_pipeline restart by `audio_pipeline_resume`.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_wait_for_stop** (*audio_pipeline_handle_t pipeline*)
The `audio_pipeline_stop` function sends requests to the elements and exits. But they need time to get rid of time-blocking tasks. This function will wait `portMAX_DELAY` until all the Elements in the pipeline actually stop.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle esp_err_t **audio_pipeline_wait_for_stop_with_ticks** (*audio_pipeline_handle_t pipeline*, TickType_t *ticks_to_wait*)

The `audio_pipeline_stop` function sends requests to the elements and exits. But they need time to get rid of time-blocking tasks. This function will wait `ticks_to_wait` until all the Elements in the pipeline actually stop.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] ticks_to_wait`: The maximum amount of time to block wait for stop

esp_err_t **audio_pipeline_link** (*audio_pipeline_handle_t pipeline*, **const** char **link_tag*[], int *link_num*)

The audio_element added to audio_pipeline will be unconnected before it is called by this function. Based on element's `name` already registered by `audio_pipeline_register`, the path of the data will be linked in the order of the link_tag. Element at index 0 is first, and index `link_num -1` is final. As well as audio_pipeline will subscribe all element's events.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `link_tag`: Array of element `name` was registered by `audio_pipeline_register`
- `[in] link_num`: Total number of elements of the `link_tag` array

esp_err_t **audio_pipeline_unlink** (*audio_pipeline_handle_t pipeline*)

Removes the connection of the elements, as well as unsubscribe events.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

*audio_element_handle_t* **audio_pipeline_get_el_by_tag** (*audio_pipeline_handle_t pipeline*, **const** char **tag*)

Find un-kept element from registered pipeline by tag.

**Return**

- NULL when any errors
- Others on success

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] tag`: A char pointer

*audio_element_handle_t* **audio_pipeline_get_el_once**(*audio_pipeline_handle_t pipeline*, **const** *audio_element_handle_t start_el*, **const** char **tag*)

Based on beginning element to find un-kept element from registered pipeline by tag.

**Return**

- NULL when any errors
- Others on success

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] start_el`: Specific beginning element
- `[in] tag`: A char pointer

esp_err_t **audio_pipeline_remove_listener**(*audio_pipeline_handle_t pipeline*)

Remove event listener from this audio_pipeline.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_set_listener**(*audio_pipeline_handle_t pipeline*, *audio_event_iface_handle_t evt*)

Set event listner for this audio_pipeline, any event from this pipeline can be listen to by `evt`

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] evt`: The Event Handle

*audio_event_iface_handle_t* **audio_pipeline_get_event_iface**(*audio_pipeline_handle_t pipeline*)

Get the event iface using by this pipeline.

**Return** The Event Handle

**Parameters**

- `[in] pipeline`: The pipeline

esp_err_t **audio_pipeline_link_insert**(*audio_pipeline_handle_t pipeline*, bool *first*, *audio_element_handle_t prev*, *ringbuf_handle_t conect_rb*, *audio_element_handle_t next*)

Insert the specific audio_element to audio_pipeline, previous element connect to the next element by ring buffer.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] pipeline`: The audio pipeline handle
- `[in] first`: Previous element is first input element, need to set `true`
- `[in] prev`: Previous element
- `[in] conect_rb`: Connect ring buffer
- `[in] next`: Next element

esp_err_t **audio_pipeline_register_more**(*audio_pipeline_handle_t pipeline*, *audio_element_handle_t element_1*, ...)

Register a NULL-terminated list of elements to audio_pipeline.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] pipeline`: The audio pipeline handle
- `[in] element_1`: The element to add to the audio_pipeline.
- `[in] ...`: Additional elements to add to the audio_pipeline.

esp_err_t **audio_pipeline_unregister_more**(*audio_pipeline_handle_t pipeline*, *audio_element_handle_t element_1*, ...)

Unregister a NULL-terminated list of elements to audio_pipeline.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] pipeline`: The audio pipeline handle
- `[in] element_1`: The element to add to the audio_pipeline.
- `[in] ...`: Additional elements to add to the audio_pipeline.

esp_err_t **audio_pipeline_link_more**(*audio_pipeline_handle_t pipeline*, *audio_element_handle_t element_1*, ...)

Adds a NULL-terminated list of elements to audio_pipeline.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] pipeline`: The audio pipeline handle
- `[in] element_1`: The element to add to the audio_pipeline.
- `[in] ...`: Additional elements to add to the audio_pipeline.

esp_err_t **audio_pipeline_listen_more** (*audio_pipeline_handle_t pipeline*, *audio_element_handle_t element_1*, ...)

Subscribe a NULL-terminated list of element's events to audio_pipeline.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] pipeline`: The audio pipeline handle
- `[in] element_1`: The element event to subscribe to the audio_pipeline.
- `[in] ...`: Additional elements event to subscribe to the audio_pipeline.

esp_err_t **audio_pipeline_check_items_state** (*audio_pipeline_handle_t pipeline*, *audio_element_handle_t dest_el*, *audio_element_status_t status*)

Update the destination element state and check the all of linked elements state are same.

**Return**

- ESP_OK All linked elements state are same.
- ESP_FAIL All linked elements state are not same.

**Parameters**

- `[in] pipeline`: The audio pipeline handle
- `[in] dest_el`: Destination element
- `[in] status`: The new status

esp_err_t **audio_pipeline_reset_items_state** (*audio_pipeline_handle_t pipeline*)

Reset pipeline element items state to `AEL_STATUS_NONE`

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_reset_ringbuffer** (*audio_pipeline_handle_t pipeline*)

Reset pipeline element ringbuffer.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_reset_elements** (*audio_pipeline_handle_t pipeline*)

Reset Pipeline linked elements state.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle

esp_err_t **audio_pipeline_reset_kept_state** (*audio_pipeline_handle_t pipeline*, *audio_element_handle_t el*)

Reset the specific element kept state.

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] el`: The Audio element Handle

esp_err_t **audio_pipeline_breakup_elements** (*audio_pipeline_handle_t pipeline*, *audio_element_handle_t kept_ctx_el*)

Break up all the linked elements of specific `pipeline`. The include and before `kept_ctx_el` working (AEL_STATE_RUNNING or AEL_STATE_PAUSED) elements and connected ringbuffer will be reserved.

**Note** There is no element reserved when `kept_ctx_el` is NULL. This function will unsubscribe all element's events.

**Return**

- ESP_OK All linked elements state are same.
- ESP_ERR_INVALID_ARG Invalid parameters.

**Parameters**

- `[in] pipeline`: The audio pipeline handle
- `[in] kept_ctx_el`: Destination keep elements

esp_err_t **audio_pipeline_relink** (*audio_pipeline_handle_t pipeline*, **const** char **link_tag*[], int *link_num*)

Basing on element's `name` already registered by `audio_pipeline_register`, relink the pipeline following the order of `names` in the `link_tag.

**Note** If the ringbuffer is not enough to connect the new pipeline will create new ringbuffer.

**Return**

- ESP_OK All linked elements state are same.
- ESP_FAIL Error.
- ESP_ERR_INVALID_ARG Invalid parameters.

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `link_tag`: Array of elements `name` that was registered by `audio_pipeline_register`
- `[in] link_num`: Total number of elements of the `link_tag` array

esp_err_t **`audio_pipeline_relink_more`** (*audio_pipeline_handle_t pipeline*, *audio_element_handle_t element_1*, *...*)

Adds a NULL-terminated list of elements to audio_pipeline.

**Note** If the ringbuffer is not enough to connect the new pipeline will create new ringbuffer.

**Return**

- ESP_OK All linked elements state are same.
- ESP_FAIL Error.
- ESP_ERR_INVALID_ARG Invalid parameters.

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] element_1`: The element to add to the audio_pipeline.
- `[in] ...`: Additional elements to add to the audio_pipeline.

esp_err_t **`audio_pipeline_change_state`** (*audio_pipeline_handle_t pipeline*, *audio_element_state_t new_state*)

Set the pipeline state.

**Return**

- ESP_OK All linked elements state are same.
- ESP_FAIL Error.

**Parameters**

- `[in] pipeline`: The Audio Pipeline Handle
- `[in] new_state`: The new state will be set

### Structures

**struct audio_pipeline_cfg**
Audio Pipeline configurations.

#### Public Members

int **rb_size**
Audio Pipeline ringbuffer size

### Macros

**DEFAULT_PIPELINE_RINGBUF_SIZE**

**DEFAULT_AUDIO_PIPELINE_CONFIG**()

### Type Definitions

**typedef struct** audio_pipeline ***audio_pipeline_handle_t**

**typedef struct** *audio_pipeline_cfg* **audio_pipeline_cfg_t**
Audio Pipeline configurations.

## 2.1.3 Event Interface

The ADF provides the Event Interface API to establish communication between Audio Elements in a pipeline. The API is built around FreeRTOS queue. It implements 'listeners' to watch for incoming messages and inform about them with a callback function.

### Application Examples

Implementation of this API is demonstrated in couple of examples including get-started/play_mp3_control.

### API Reference

### Header File

- audio_pipeline/include/audio_event_iface.h

### Functions

*audio_event_iface_handle_t* **audio_event_iface_init**(*audio_event_iface_cfg_t* **config*)
Initialize audio event.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `config`: The configurations

esp_err_t **audio_event_iface_destroy** (*audio_event_iface_handle_t evt*)

Cleanup event, it doesn't free evt pointer.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `evt`: The event

esp_err_t **audio_event_iface_set_listener** (*audio_event_iface_handle_t evt*, *audio_event_iface_handle_t listener*)

Add audio event `evt` to the listener, then we can listen `evt` event from `listen`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `listener`: The event can listen another event
- `evt`: The event to be added to

esp_err_t **audio_event_iface_remove_listener** (*audio_event_iface_handle_t listener*, *audio_event_iface_handle_t evt*)

Remove audio event `evt` from the listener.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `listener`: The event listener
- `evt`: The event to be removed from

esp_err_t **audio_event_iface_set_cmd_waiting_timeout** (*audio_event_iface_handle_t evt*, TickType_t *wait_time*)

Set current queue wait time for the event.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `evt`: The event
- `[in] wait_time`: The wait time

esp_err_t **audio_event_iface_waiting_cmd_msg**(*audio_event_iface_handle_t evt*)
Waiting internal queue message.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `evt`: The event

esp_err_t **audio_event_iface_cmd**(*audio_event_iface_handle_t evt*, *audio_event_iface_msg_t *msg*)
Trigger an event for internal queue with a message.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `evt`: The event
- `msg`: The message

esp_err_t **audio_event_iface_cmd_from_isr**(*audio_event_iface_handle_t evt*, *audio_event_iface_msg_t *msg*)
It's same with `audio_event_iface_cmd`, but can send a message from ISR.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] evt`: The event
- `msg`: The message

esp_err_t **audio_event_iface_sendout**(*audio_event_iface_handle_t evt*, *audio_event_iface_msg_t *msg*)
Trigger and event out with a message.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `evt`: The event
- `msg`: The message

esp_err_t **audio_event_iface_discard**(*audio_event_iface_handle_t evt*)
Discard all ongoing event message.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `evt`: The event

esp_err_t **audio_event_iface_listen**(*audio_event_iface_handle_t evt*, *audio_event_iface_msg_t *msg*, TickType_t *wait_time*)

Listening and invoke callback function if there are any event are comming.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `evt`: The event
- `msg`: The message
- `wait_time`: The wait time

QueueHandle_t **audio_event_iface_get_queue_handle**(*audio_event_iface_handle_t evt*)

Get External queue handle of Emmitter.

**Return** External QueueHandle_t

**Parameters**

- `[in] evt`: The external queue

esp_err_t **audio_event_iface_read**(*audio_event_iface_handle_t evt*, *audio_event_iface_msg_t *msg*, TickType_t *wait_time*)

Read the event from all the registered event emitters in the queue set of the interface.

**Return**

- ESP_OK On successful receiving of event
- ESP_FAIL In case of a timeout or invalid parameter passed

**Parameters**

- `[in] evt`: The event interface
- `[out] msg`: The pointer to structure in which event is to be received
- `[in] wait_time`: Timeout for receiving event

QueueHandle_t **audio_event_iface_get_msg_queue_handle**(*audio_event_iface_handle_t evt*)

Get Internal queue handle of Emmitter.

**Return** Internal QueueHandle_t

**Parameters**

- `[in] evt`: The Internal queue

esp_err_t **audio_event_iface_set_msg_listener**(*audio_event_iface_handle_t* *evt*, *audio_event_iface_handle_t* *listener*)

Add audio internal event `evt` to the listener, then we can listen `evt` event from `listen`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `listener`: The event can listen another event
- `evt`: The event to be added to

## Structures

**struct audio_event_iface_msg_t**

Event message

### Public Members

int **cmd**

Command id

void ***data**

Data pointer

int **data_len**

Data length

void ***source**

Source event

int **source_type**

Source type (To know where it came from)

bool **need_free_data**

Need to free data pointer after the event has been processed

**struct audio_event_iface_cfg_t**

Event interface configurations

### Public Members

int **internal_queue_size**

It's optional, Queue size for event `internal_queue`

int **external_queue_size**

It's optional, Queue size for event `external_queue`

int **queue_set_size**

It's optional, QueueSet size for event `queue_set`

*on_event_iface_func* **on_cmd**

Function callback for listener when any event arrived

void ***context**
Context will pass to callback function

TickType_t **wait_time**
Timeout to check for event queue

int **type**
it will pass to *audio_event_iface_msg_t* source_type (To know where it came from)

### Macros

**DEFAULT_AUDIO_EVENT_IFACE_SIZE**

**AUDIO_EVENT_IFACE_DEFAULT_CFG**()

### Type Definitions

**typedef** esp_err_t (***on_event_iface_func**) (*audio_event_iface_msg_t* *, void *)

**typedef struct** audio_event_iface ***audio_event_iface_handle_t**

## 2.1.4 Audio Common

Enumerations that define type of *Audio Elements*, type and format of *Codecs* and type of *Streams*.

### API Reference

### Header File

- audio_pipeline/include/audio_common.h

### Macros

**ELEMENT_SUB_TYPE_OFFSET**

**mem_assert**(x)

### Enumerations

**enum audio_element_type_t**
*Values:*

**AUDIO_ELEMENT_TYPE_UNKNOW** = 0x01 << ELEMENT_SUB_TYPE_OFFSET

**AUDIO_ELEMENT_TYPE_ELEMENT** = 0x01 << (ELEMENT_SUB_TYPE_OFFSET + 1)

**AUDIO_ELEMENT_TYPE_PLAYER** = 0x01 << (ELEMENT_SUB_TYPE_OFFSET + 2)

**AUDIO_ELEMENT_TYPE_SERVICE** = 0x01 << (ELEMENT_SUB_TYPE_OFFSET + 3)

**AUDIO_ELEMENT_TYPE_PERIPH** = 0x01 << (ELEMENT_SUB_TYPE_OFFSET + 4)

**enum audio_stream_type_t**
*Values:*

**AUDIO_STREAM_NONE** = 0

**AUDIO_STREAM_READER**

**AUDIO_STREAM_WRITER**

**enum audio_codec_type_t**

*Values:*

**AUDIO_CODEC_TYPE_NONE** = 0

**AUDIO_CODEC_TYPE_DECODER**

**AUDIO_CODEC_TYPE_ENCODER**

## 2.1.5 ESP Audio

This component provides several simple high level APIs. It is intended for quick implementation of audio applications based on typical interconnections of standardized audio elements.

### API Reference

### Header File

- esp-adf-libs/esp_audio/include/audio_def.h

### Structures

**struct esp_audio_state_t**

esp_audio status information parameters

#### Public Members

*esp_audio_status_t* **status**

Status of esp_audio

*audio_err_t* **err_msg**

Status is `AUDIO_STATUS_ERROR`, err_msg will be setup

*media_source_type_t* **media_src**

Media source type

### Macros

**ESP_ERR_AUDIO_BASE**

Starting number of ESP audio error codes

### Type Definitions

**typedef** void (***esp_audio_event_callback**) (*esp_audio_state_t* *audio, void *ctx)

**typedef** esp_err_t (***audio_volume_set**) (void *hd, int vol)

**typedef** esp_err_t (***audio_volume_get**) (void *hd, int *vol)

### Enumerations

**enum audio_err_t**

*Values:*

**ESP_ERR_AUDIO_NO_ERROR** = ESP_OK

**ESP_ERR_AUDIO_FAIL** = ESP_FAIL

**ESP_ERR_AUDIO_NO_INPUT_STREAM** = ESP_ERR_AUDIO_BASE + 1

**ESP_ERR_AUDIO_NO_OUTPUT_STREAM** = ESP_ERR_AUDIO_BASE + 2

**ESP_ERR_AUDIO_NO_CODEC** = ESP_ERR_AUDIO_BASE + 3

**ESP_ERR_AUDIO_HAL_FAIL** = ESP_ERR_AUDIO_BASE + 4

**ESP_ERR_AUDIO_MEMORY_LACK** = ESP_ERR_AUDIO_BASE + 5

**ESP_ERR_AUDIO_INVALID_URI** = ESP_ERR_AUDIO_BASE + 6

**ESP_ERR_AUDIO_INVALID_PATH** = ESP_ERR_AUDIO_BASE + 7

**ESP_ERR_AUDIO_INVALID_PARAMETER** = ESP_ERR_AUDIO_BASE + 8

**ESP_ERR_AUDIO_NOT_READY** = ESP_ERR_AUDIO_BASE + 9

**ESP_ERR_AUDIO_NOT_SUPPORT** = ESP_ERR_AUDIO_BASE + 10

**ESP_ERR_AUDIO_TIMEOUT** = ESP_ERR_AUDIO_BASE + 11

**ESP_ERR_AUDIO_ALREADY_EXISTS** = ESP_ERR_AUDIO_BASE + 12

**ESP_ERR_AUDIO_LINK_FAIL** = ESP_ERR_AUDIO_BASE + 13

**ESP_ERR_AUDIO_UNKNOWN** = ESP_ERR_AUDIO_BASE + 14

**ESP_ERR_AUDIO_OUT_OF_RANGE** = ESP_ERR_AUDIO_BASE + 15

**ESP_ERR_AUDIO_STOP_BY_USER** = ESP_ERR_AUDIO_BASE + 16

**ESP_ERR_AUDIO_OPEN** = ESP_ERR_AUDIO_BASE + 0x100

**ESP_ERR_AUDIO_INPUT** = ESP_ERR_AUDIO_BASE + 0x101

**ESP_ERR_AUDIO_PROCESS** = ESP_ERR_AUDIO_BASE + 0x102

**ESP_ERR_AUDIO_OUTPUT** = ESP_ERR_AUDIO_BASE + 0x103

**ESP_ERR_AUDIO_CLOSE** = ESP_ERR_AUDIO_BASE + 0x104

**enum esp_audio_status_t**

*Values:*

**AUDIO_STATUS_UNKNOWN** = 0

**AUDIO_STATUS_RUNNING** = 1

**AUDIO_STATUS_PAUSED** = 2

**AUDIO_STATUS_STOPPED** = 3

**AUDIO_STATUS_FINISHED** = 4

**AUDIO_STATUS_ERROR** = 5

**enum audio_termination_type_t**
*Values:*

**TERMINATION_TYPE_NOW** = 0
Audio operation will be terminated immediately

**TERMINATION_TYPE_DONE** = 1
Audio operation will be stopped when finished

**TERMINATION_TYPE_MAX**

**enum esp_audio_prefer_t**
*Values:*

**ESP_AUDIO_PREFER_MEM** = 0

**ESP_AUDIO_PREFER_SPEED** = 1

**enum media_source_type_t**
*Values:*

**MEDIA_SRC_TYPE_NULL** = 0

**MEDIA_SRC_TYPE_MUSIC_BASE** = 0x100

**MEDIA_SRC_TYPE_MUSIC_SD** = *MEDIA_SRC_TYPE_MUSIC_BASE* + 1

**MEDIA_SRC_TYPE_MUSIC_HTTP** = *MEDIA_SRC_TYPE_MUSIC_BASE* + 2

**MEDIA_SRC_TYPE_MUSIC_FLASH** = *MEDIA_SRC_TYPE_MUSIC_BASE* + 3

**MEDIA_SRC_TYPE_MUSIC_A2DP** = *MEDIA_SRC_TYPE_MUSIC_BASE* + 4

**MEDIA_SRC_TYPE_MUSIC_DLNA** = *MEDIA_SRC_TYPE_MUSIC_BASE* + 5

**MEDIA_SRC_TYPE_MUSIC_RAW** = *MEDIA_SRC_TYPE_MUSIC_BASE* + 6

**MEDIA_SRC_TYPE_MUSIC_MAX** = 0x1FF

**MEDIA_SRC_TYPE_TONE_BASE** = 0x200

**MEDIA_SRC_TYPE_TONE_SD** = *MEDIA_SRC_TYPE_TONE_BASE* + 1

**MEDIA_SRC_TYPE_TONE_HTTP** = *MEDIA_SRC_TYPE_TONE_BASE* + 2

**MEDIA_SRC_TYPE_TONE_FLASH** = *MEDIA_SRC_TYPE_TONE_BASE* + 3

**MEDIA_SRC_TYPE_TONE_MAX** = 0x2FF

**MEDIA_SRC_TYPE_RESERVE_BASE** = 0x800

**MEDIA_SRC_TYPE_RESERVE_MAX** = 0xFFF

### Header File

- esp-adf-libs/esp_audio/include/esp_audio.h

### Functions

*esp_audio_handle_t* **esp_audio_create**(const *esp_audio_cfg_t* **cfg*)

Create esp_audio instance according to 'cfg' parameter.

This function create an esp_audio instance, at the specified configuration.

**Return**

- NULL: Error
- Others: esp_audio instance fully certifying

**Parameters**

- `[in] cfg`: Provide esp_audio initialization configuration

*audio_err_t* **esp_audio_destroy**(*esp_audio_handle_t handle*)

Specific esp_audio instance will be destroyed.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: no instance to free, call esp_audio_init first

**Parameters**

- `[in] handle`: The esp_audio instance

*audio_err_t* **esp_audio_input_stream_add**(*esp_audio_handle_t handle*, *audio_element_handle_t in_stream*)

Add audio input stream to specific esp_audio instance.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments
- ESP_ERR_AUDIO_MEMORY_LACK: allocate memory fail

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] in_stream`: Audio stream instance

*audio_err_t* **esp_audio_output_stream_add**(*esp_audio_handle_t handle*, *audio_element_handle_t out_stream*)

Add audio output stream to specific esp_audio instance.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

- ESP_ERR_AUDIO_MEMORY_LACK: allocate memory fail

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] out_stream`: The audio stream element instance

*audio_err_t* **esp_audio_codec_lib_add**(*esp_audio_handle_t handle*, *audio_codec_type_t type*, *audio_element_handle_t lib*)

Add a new codec lib that can decode or encode a music file.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments
- ESP_ERR_AUDIO_MEMORY_LACK: allocate memory fail

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] type`: The audio codec type(encoder or decoder)
- `[in] lib`: To provide audio stream element

*audio_err_t* **esp_audio_codec_lib_query**(*esp_audio_handle_t handle*, *audio_codec_type_t type*, **const** char **extension*)

Check if this kind of music extension is supported or not.

**Note** This function just query the codec which has already add by esp_audio_codec_lib_add. The max length of extension is 6.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: supported
- ESP_ERR_AUDIO_NOT_SUPPORT: not support
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] type`: The CODEC_ENCODER or CODEC_DECODER
- `[in] extension`: Such as "mp3", "wav", "aac"

*audio_err_t* **esp_audio_play**(*esp_audio_handle_t handle*, *audio_codec_type_t type*, **const** char **uri*, int *pos*)

Play the given uri.

The esp_audio_play have follow activity, setup inputstream, outputstream and codec by uri, start all of them. There is a rule that esp_audio will select input stream, codec and output stream by URI field.

Rule of URI field are as follow.

- `UF_SCHEMA` field of URI for choose input stream from existing streams. e.g:"http","file"
- `UF_PATH` field of URI for choose codec from existing codecs. e.g:"/audio/mp3_music.mp3"
- `UF_FRAGMENT` field of URI for choose output stream from existing streams, output stream is I2S by default.

- `UF_USERINFO` field of URI for specific sample rate and channels at encode mode.

The format "user:password" in the userinfo field, "user" is sample rate, "password" is channels.

Now esp_audio_play support follow URIs.

- "https://dl.espressif.com/dl/audio/mp3_music.mp3"
- "http://media-ice.musicradio.com/ClassicFMMP3"
- "file://sdcard/test.mp3"
- "iis://16000:2@from.pcm/rec.wav#file"
- "iis://16000:1@record.pcm/record.wav#raw"
- "aadp://44100:2@bt/sink/stream.pcm"
- "hfp://8000:1@bt/hfp/stream.pcm"

**Note**

- The URI parse by `http_parser_parse_url`,any illegal string will be return `ESP_ERR_AUDIO_INVALID_URI`.
- If the esp_decoder codec is added to `handle`, then the `handle` of esp_decoder will be set as the default decoder, even if other decoders are added.
- Enabled `CONFIG_FATFS_API_ENCODING_UTF_8`, the URI can be support Chinese characters.
- Asynchronous interface
- The maximum of block time can be modify by `esp_audio_play_timeout_set`, default value is 25 seconds.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_TIMEOUT: timeout the play activity
- ESP_ERR_AUDIO_NOT_SUPPORT: Currently status is AUDIO_STATUS_RUNNING
- ESP_ERR_AUDIO_INVALID_URI: URI is illegal
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments
- ESP_ERR_AUDIO_STOP_BY_USER: Exit without play due to esp_audio_stop has been called.

**Parameters**

- `handle`: The esp_audio_handle_t instance
- `uri`: Such as "file://sdcard/test.wav" or "http://iot.espressif.com/file/example.mp3". If NULL to be set, the uri setup by`esp_audio_setup` will used.
- `type`: Specific handle type decoder or encoder
- `pos`: Specific starting position by bytes

*audio_err_t* **esp_audio_sync_play** (*esp_audio_handle_t handle*, **const** char **uri*, int *pos*)
Play the given uri until music finished or error occured.

**Note**

- All features are same with `esp_audio_play`
- Synchronous interface

- Support decoder mode only
- No any events post during playing

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_TIMEOUT: timeout the play activity
- ESP_ERR_AUDIO_NOT_SUPPORT: Currently status is AUDIO_STATUS_RUNNING
- ESP_ERR_AUDIO_INVALID_URI: URI is illegal
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `handle`: The esp_audio_handle_t instance
- `uri`: Such as "file://sdcard/test.wav" or "http://iot.espressif.com/file/example.mp3",
- `pos`: Specific starting position by bytes

*audio_err_t* **esp_audio_stop**(*esp_audio_handle_t handle*, *audio_termination_type_t type*)

A synchronous interface for stop the esp_audio. The maximum of block time is 8000ms.

**Note** 1. If user queue has been registered by evt_que, AUDIO_STATUS_STOPPED event for success or AUDIO_STATUS_ERROR event for error will be received.

1. `TERMINATION_TYPE_DONE` only works with input stream which can't stopped by itself, e.g. `raw read/write stream`, others streams are no effect.
2. The synchronous interface is used to ensure that working pipeline is stopped.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments
- ESP_ERR_AUDIO_NOT_READY: The status is not AUDIO_STATUS_RUNNING or AUDIO_STATUS_PAUSED or element has not created
- ESP_ERR_AUDIO_TIMEOUT: timeout(8000ms) the stop activity.

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] type`: Stop immediately or done

*audio_err_t* **esp_audio_pause**(*esp_audio_handle_t handle*)

Pause the esp_audio.

**Note** 1. Only support music and without live stream. If user queue has been registered by evt_que, AUDIO_STATUS_PAUSED event for success or AUDIO_STATUS_ERROR event for error will be received.

1. The Paused music must be stoped by `esp_audio_stop` before new playing, otherwise got block on new play.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

- ESP_ERR_AUDIO_NOT_READY: the status is not running
- ESP_ERR_AUDIO_TIMEOUT: timeout the pause activity.

**Parameters**

- `[in] handle`: The esp_audio instance

*audio_err_t* **esp_audio_resume**(*esp_audio_handle_t handle*)

Resume the music paused.

**Note** Only support music and without live stream. If user queue has been registered by evt_que, AUDIO_STATUS_RUNNING event for success or AUDIO_STATUS_ERROR event for error will be received.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments
- ESP_ERR_AUDIO_TIMEOUT: timeout the resume activity.

**Parameters**

- `[in] handle`: The esp_audio instance

*audio_err_t* **esp_audio_eq_gain_set**(*esp_audio_handle_t handle*, int *band_index*, int *nch*, int *eq_gain*)

Set the audio gain to be processed by the equalizer.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] band_index`: The position of center frequencies of equalizer. The range of eq band index is [0 - 9].
- `[in] nch`: The number of channel. As for mono, the nch can only set to 1. As for dual, thc nch can set to 1 and 2.
- `[in] eq_gain`: The value of audio gain which in `band_index`.

*audio_err_t* **esp_audio_eq_gain_get**(*esp_audio_handle_t handle*, int *band_index*, int *nch*, int **eq_gain*)

Get the audio gain to be processed by the equalizer.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: Audio element handle
- `[in] band_index`: The position of center frequencies of equalizer. The range of eq band index is [0 - 9].

- `[in] nch`: The number of channel. As for mono, the nch can only set to 1. As for dual, thc nch can set to 1 and 2.
- `[out] eq_gain`: The pointer of the gain processed by equalizer

*audio_err_t* **esp_audio_speed_get** (*esp_audio_handle_t handle*, *esp_audio_play_speed_t *speed_index*)

Getting esp_audio play speed index, index value is from "esp_audio_speed_t" enum.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] speed_index`: Current audio play speed index.

*audio_err_t* **esp_audio_speed_set** (*esp_audio_handle_t handle*, *esp_audio_play_speed_t speed_index*)

Use speed_index which is from "esp_audio_speed_t" enum to set esp_audio play speed.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] speed_index`: Value from "esp_audio_speed_t" enum.

*audio_err_t* **esp_audio_speed_idx_to_float** (*esp_audio_handle_t handle*, *esp_audio_play_speed_t speed_index*, float **speed*)

Use speed_index which is from "esp_audio_speed_t" enum to get esp_audio play speed which is float type.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] speed_index`: Current audio play speed index.
- `[out] speed`: Current audio play speed.

*audio_err_t* **esp_audio_vol_set** (*esp_audio_handle_t handle*, int *vol*)

Setting esp_audio volume.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_CTRL_HAL_FAIL: error with hardware.
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] vol`: Specific volume will be set. 0-100 is legal. 0 will be mute.

*audio_err_t* **esp_audio_vol_get** (*esp_audio_handle_t handle*, int **vol*)

Get esp_audio volume.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_CTRL_HAL_FAIL: error with hardware.
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] vol`: A pointer to int that indicates esp_audio volume.

*audio_err_t* **esp_audio_state_get** (*esp_audio_handle_t handle*, *esp_audio_state_t *state*)

Get esp_audio status.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: no esp_audio instance or esp_audio does not playing

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] state`: A pointer to *esp_audio_state_t* that indicates esp_audio status.

*audio_err_t* **esp_audio_pos_get** (*esp_audio_handle_t handle*, int **pos*)

Get the position in bytes of currently played music.

**Note** This function works only with decoding music.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: no esp_audio instance
- ESP_ERR_AUDIO_NOT_READY: no codec element

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] pos`: A pointer to int that indicates esp_audio decoding position.

*audio_err_t* **esp_audio_time_get** (*esp_audio_handle_t handle*, int **time*)

Get the position in microseconds of currently played music.

**Note** This function works only with decoding music.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success

- ESP_ERR_AUDIO_INVALID_PARAMETER: no esp_audio instance
- ESP_ERR_AUDIO_NOT_READY: no out stream

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] time`: A pointer to int that indicates esp_audio decoding position.

*audio_err_t* **esp_audio_setup**(*esp_audio_handle_t handle*, *esp_audio_setup_t *sets*)

Choose the `in_stream`, `codec` and `out_stream` definitely, and set `uri`.

**Note** This function provide a manual way to select in/out stream and codec, should be called before the `esp_audio_play`, then ignore the `esp_audio_play` URI parameter only one time.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: no esp_audio instance
- ESP_ERR_AUDIO_MEMORY_LACK: allocate memory fail

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] sets`: A pointer to *esp_audio_setup_t*.

*audio_err_t* **esp_audio_media_type_set**(*esp_audio_handle_t handle*, *media_source_type_t type*)

*audio_err_t* **esp_audio_music_info_get**(*esp_audio_handle_t handle*, *esp_audio_music_info_t *info*)

*audio_err_t* **esp_audio_info_get**(*esp_audio_handle_t handle*, *esp_audio_info_t *info*)

*audio_err_t* **esp_audio_info_set**(*esp_audio_handle_t handle*, *esp_audio_info_t *info*)

*audio_err_t* **esp_audio_callback_set**(*esp_audio_handle_t handle*, *esp_audio_event_callback cb*, void **cb_ctx*)

*audio_err_t* **esp_audio_seek**(*esp_audio_handle_t handle*, int *seek_time_sec*)

Seek the position in second of currently played music.

**Note** This function works only with decoding music.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_FAIL: codec or allocation fail
- ESP_ERR_AUDIO_TIMEOUT: timeout for sync the element status
- ESP_ERR_AUDIO_INVALID_PARAMETER: no esp_audio instance
- ESP_ERR_AUDIO_NOT_SUPPORT: codec has finished
- ESP_ERR_AUDIO_OUT_OF_RANGE: the seek_time_ms is out of the range
- ESP_ERR_AUDIO_NOT_READY: the status is neither running nor paused

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] seek_time_sec`: A pointer to int that indicates esp_audio decoding position.

*audio_err_t* **esp_audio_duration_get** (*esp_audio_handle_t handle*, int **duration*)
Get the duration in microseconds of playing music.

**Note** This function works only with decoding music.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: no esp_audio instance
- ESP_ERR_AUDIO_NOT_READY: no codec element or no in element

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] duration`: A pointer to int that indicates decoding total time.

*audio_err_t* **esp_audio_play_timeout_set** (*esp_audio_handle_t handle*, int *time_ms*)
Setting the maximum amount of time to waiting for `esp_audio_play` only.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: invalid arguments

**Parameters**

- `[in] handle`: The esp_audio instance
- `[in] time_ms`: The maximum amount of time

*audio_err_t* **esp_audio_prefer_type_get** (*esp_audio_handle_t handle*, *esp_audio_prefer_t *type*)
Get the type of `esp_audio_prefer_t`

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: no esp_audio instance

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] type`: A pointer to esp_audio_prefer_t

*audio_err_t* **esp_audio_event_que_set** (*esp_audio_handle_t handle*, QueueHandle_t *que*)
Set event queue to notify the esp_audio status.

**Return**

- ESP_ERR_AUDIO_NO_ERROR: on success
- ESP_ERR_AUDIO_INVALID_PARAMETER: no esp_audio instance

**Parameters**

- `[in] handle`: The esp_audio instance
- `[out] que`: A pointer to QueueHandle_t

### Structures

**struct esp_audio_cfg_t**
esp_audio configuration parameters

#### Public Members

int **in_stream_buf_size**
Input buffer size

int **out_stream_buf_size**
Output buffer size

int **resample_rate**
Destination sample rate, 0: disable resample; others: 44.1K, 48K, 32K, 16K, 8K has supported It should be make sure same with I2S stream `sample_rate`

int **component_select**
The select of audio forge component. eg. To choose equalizer and ALC together, please enter ESP_AUDIO_COMPONENT_SELECT_ALC | ESP_AUDIO_COMPONENT_SELECT_EQUALIZER.

QueueHandle_t **evt_que**
For received esp_audio events (optional)

*esp_audio_event_callback* **cb_func**
esp_audio events callback (optional)

void ***cb_ctx**
esp_audio callback context (optional)

*esp_audio_prefer_t* **prefer_type**
esp_audio works on sepcific type, default memory is preferred.

- `ESP_AUDIO_PREFER_MEM` mode stopped the previous linked elements before the new pipeline starting, except out stream element.
- `ESP_AUDIO_PREFER_SPEED` mode kept the previous linked elements before the new pipeline starting, except out stream element.

void ***vol_handle**
Volume change instance

*audio_volume_set* **vol_set**
Set volume callback

*audio_volume_get* **vol_get**
Get volume callback

int **task_prio**
esp_audio task priority

int **task_stack**
Size of esp_audio task stack

**struct esp_audio_setup_t**
esp_audio setup parameters by manual

### Public Members

*audio_codec_type_t* **set_type**
Set codec type

int **set_sample_rate**
Set music sample rate

int **set_channel**
Set music channels

int **set_pos**
Set starting position

int **set_time**
Set starting position of the microseconds time (optional)

char ***set_uri**
Set URI

char ***set_in_stream**
Tag of in_stream

char ***set_codec**
Tag of the codec

char ***set_out_stream**
Tag of out_stream

**struct esp_audio_info_t**
esp_audio information

### Public Members

*audio_element_info_t* **codec_info**
Codec information

*audio_element_handle_t* **in_el**
Handle of the in stream

*audio_element_handle_t* **out_el**
Handle of the out stream

*audio_element_handle_t* **codec_el**
Handle of the codec

*audio_element_handle_t* **filter_el**
Handle of the filter

*esp_audio_state_t* **st**
The state of esp_audio

int **time_pos**
Position of the microseconds time

float **audio_speed**
Play speed of audio

int64_t **in_stream_total_size**
Total size of in stream

**struct esp_audio_music_info_t**
The music informations.

### Public Members

int **sample_rates**
Sample rates in Hz

int **channels**
Number of audio channel, mono is 1, stereo is 2

int **bits**
Bit wide (8, 16, 24, 32 bits)

int **bps**
Bit per second

esp_codec_type_t **codec_fmt**
Music format

## Macros

**ESP_AUDIO_COMPONENT_SELECT_DEFAULT**
Default selected

**ESP_AUDIO_COMPONENT_SELECT_ALC**
ALC selected

**ESP_AUDIO_COMPONENT_SELECT_EQUALIZER**
Equalizer selected

**DEFAULT_ESP_AUDIO_CONFIG**()

## Type Definitions

**typedef** void ***esp_audio_handle_t**

## Enumerations

**enum esp_audio_play_speed_t**
esp_audio play speed

*Values:*

**ESP_AUDIO_PLAY_SPEED_UNKNOW** = -1

**ESP_AUDIO_PLAY_SPEED_0_50** = 0

**ESP_AUDIO_PLAY_SPEED_0_75** = 1

**ESP_AUDIO_PLAY_SPEED_1_00** = 2

**ESP_AUDIO_PLAY_SPEED_1_25** = 3

**ESP_AUDIO_PLAY_SPEED_1_50** = 4

**ESP_AUDIO_PLAY_SPEED_1_75** = 5

**ESP_AUDIO_PLAY_SPEED_2_00** = 6

**ESP_AUDIO_PLAY_SPEED_MAX** = 7

## 2.2 Audio Streams

[]

The Audio Stream refers to an *Audio Element* that is responsible for acquiring of audio data and then sending the data out after processing.

The following stream types are supported:

- *Algorithm Stream*
- *FatFs Stream*
- *HTTP Stream*
- *I2S Stream*
- *PWM Stream*
- *Raw Stream*
- *SPIFFS Stream*
- *TCP Client Stream*
- *Tone Stream*
- *Flash-Embedding Stream*
- *TTS Stream*

Each stream is initialized with a structure as an input, and the returned `audio_element_handle_t` handle is used to call the functions in `audio_element.h`. Most streams have two types, `AUDIO_STREAM_READER` (reader) and `AUDIO_STREAM_WRITER` (writer). For example, to set the I2S stream type, use *`i2s_stream_init()`* and *`i2s_stream_cfg_t`*.

See description below for the API details.

### 2.2.1 Algorithm Stream

The algorithm stream integrates front-end algorithms such as acoustic echo cancellation (AEC), automatic gain control (AGC), and noise suppression (NS) to process the received audio. It is often used in audio preprocessing scenarios, including VoIP, speech recognition, and keyword wake-up. The stream calls esp-sr and thus occupies large memory. The stream only supports the `AUDIO_STREAM_READER` type.

### Application Example

- advanced_examples/algorithm/main/algorithm_examples.c
- protocols/voip/main/voip_app.c

### Header File

- audio_stream/include/algorithm_stream.h

### Functions

*audio_element_handle_t* **algo_stream_init**(*algorithm_stream_cfg_t* **config*)

Initialize algorithm stream.

**Return** The audio element handle

**Parameters**

- `config`: The algorithm Stream configuration

*audio_element_err_t* **algo_stream_set_delay**(*audio_element_handle_t el*, *ringbuf_handle_t ringbuf*, int *delay_ms*)

Set playback signal or recording signal delay when use type2.

**Note** The AEC internal buffering mechanism requires that the recording signal is delayed by around 0 - 10 ms compared to the corresponding reference (playback) signal.

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `el`: Handle of element
- `ringbuf`: Handle of ringbuf
- `delay_ms`: The delay between playback and recording in ms This delay_ms can be debugged by yourself, you can set the configuration debug_input to true, then get the original input data (left channel is the signal captured from the microphone, right channel is the signal played to the speaker), and check the delay with an audio analysis tool.

esp_err_t **algorithm_mono_fix**(uint8_t **sbuff*, uint32_t *len*)

Fix I2S mono noise issue.

**Note** This API only for ESP32 with I2S 16bits

**Return** ESP_OK

**Parameters**

- `sbuff`: I2S data buffer
- `len`: I2S data len

### Structures

**struct algorithm_stream_cfg_t**

Algorithm stream configurations.

#### Public Members

*algorithm_stream_input_type_t* **input_type**
Input type of stream

int **task_stack**
Task stack size

int **task_prio**
Task peroid

int **task_core**
The core that task to be created

int **out_rb_size**
Size of output ringbuffer

bool **stack_in_ext**
Try to allocate stack in external memory

int **rec_linear_factor**
The linear amplication factor of record signal

int **ref_linear_factor**
The linear amplication factor of reference signal

bool **debug_input**
debug algorithm input data

bool **swap_ch**
Swap left and right channels

int8_t **algo_mask**
Choose algorithm to use

int **sample_rate**
The sampling rate of the input PCM (in Hz)

int **mic_ch**
MIC channel num

int **agc_gain**
AGC gain(dB) for voice communication

bool **aec_low_cost**
AEC uses less cpu and ram resources, but has poor suppression of nonlinear distortion

char ***partition_label**
Partition label which stored the model data

### Macros

**ALGORITHM_STREAM_PINNED_TO_CORE**

**ALGORITHM_STREAM_TASK_PERIOD**

**ALGORITHM_STREAM_RINGBUFFER_SIZE**

**ALGORITHM_STREAM_TASK_STACK_SIZE**

**ALGORITHM_STREAM_DEFAULT_SAMPLE_RATE_HZ**

**ALGORITHM_STREAM_DEFAULT_SAMPLE_BIT**

**ALGORITHM_STREAM_DEFAULT_MIC_CHANNELS**

**ALGORITHM_STREAM_DEFAULT_AGC_GAIN_DB**

**ALGORITHM_STREAM_DEFAULT_MASK**

**ALGORITHM_STREAM_CFG_DEFAULT**()

### Enumerations

**enum algorithm_stream_input_type_t**

Two types of algorithm stream input method.

*Values:*

**ALGORITHM_STREAM_INPUT_TYPE1** = 0

Type 1 is default used by mini-board, the reference signal and the recording signal are respectively read in from the left channel and the right channel of the same I2S

**ALGORITHM_STREAM_INPUT_TYPE2** = 1

As the simple diagram above shows, when type2 is choosen, the recording signal and reference signal should be input by users.

**enum algorithm_stream_mask_t**

Choose the algorithm to be used.

*Values:*

**ALGORITHM_STREAM_USE_AEC** = (0x1 << 0)

Use AEC

**ALGORITHM_STREAM_USE_AGC** = (0x1 << 1)

Use AGC

**ALGORITHM_STREAM_USE_NS** = (0x1 << 2)

Use NS

**ALGORITHM_STREAM_USE_VAD** = (0x1 << 3)

Use VAD

### 2.2.2 FatFs Stream

The FatFs stream reads and writes data from FatFs. It has two types: "reader" and "writer". The type is defined by `audio_stream_type_t`.

#### Application Example

- Reader example: player/pipeline_play_sdcard_music
- Writer example: recorder/pipeline_recording_to_sdcard

#### Header File

- audio_stream/include/fatfs_stream.h

#### Functions

*audio_element_handle_t* **fatfs_stream_init** (*fatfs_stream_cfg_t *config*)

Create a handle to an Audio Element to stream data from FatFs to another Element or get data from other elements written to FatFs, depending on the configuration the stream type, either AUDIO_STREAM_READER or AUDIO_STREAM_WRITER.

**Return** The Audio Element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct fatfs_stream_cfg_t**

FATFS Stream configurations, if any entry is zero then the configuration will be set to default values.

##### Public Members

*audio_stream_type_t* **type**

Stream type

int **buf_sz**

Audio Element Buffer size

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

Task running in core (0 or 1)

int **task_prio**

Task priority (based on freeRTOS priority)

bool **ext_stack**

Allocate stack on extern ram

bool **write_header**

Choose to write amrnb/amrwb header in fatfs whether or not (true or false, true means choose to write amrnb header)

### Macros

**FATFS_STREAM_BUF_SIZE**

**FATFS_STREAM_TASK_STACK**

**FATFS_STREAM_TASK_CORE**

**FATFS_STREAM_TASK_PRIO**

**FATFS_STREAM_RINGBUFFER_SIZE**

**FATFS_STREAM_CFG_DEFAULT**()

## 2.2.3 HTTP Stream

The HTTP stream obtains and sends data through `esp_http_client()`. The stream has two types: "reader" and "writer", and the type is defined by *audio_stream_type_t*. `AUDIO_STREAM_READER` supports HTTP, HTTPS, HTTP Live Stream, and other protocols. Make sure the network is connected before using the stream.

### Application Example

- Reader example
  - player/pipeline_living_stream
  - player/pipeline_http_mp3
- Writer example
  - recorder/pipeline_raw_http

### Header File

- audio_stream/include/http_stream.h

### Functions

*audio_element_handle_t* **http_stream_init**(*http_stream_cfg_t *config*)

Create a handle to an Audio Element to stream data from HTTP to another Element or get data from other elements sent to HTTP, depending on the configuration the stream type, either AUDIO_STREAM_READER or AUDIO_STREAM_WRITER.

**Return** The Audio Element handle

**Parameters**

- `config`: The configuration

esp_err_t **http_stream_next_track**(*audio_element_handle_t el*)

Connect to next track in the playlist.

```
        This function can be used in event_handler of http_stream.
        User can call this function to connect to next track in playlist when he/
↪she gets `HTTP_STREAM_FINISH_TRACK` event
```

**Return**

- ESP_OK on success
- ESP_FAIL on errors

**Parameters**

- `el`: The http_stream element handle

esp_err_t **`http_stream_restart`** (*audio_element_handle_t el*)

esp_err_t **`http_stream_fetch_again`** (*audio_element_handle_t el*)

Try to fetch the tracks again.

```
        If this is live stream we will need to keep fetching URIs.
```

**Return**

- ESP_OK on success
- ESP_ERR_NOT_SUPPORTED if playlist is finished

**Parameters**

- `el`: The http_stream element handle

esp_err_t **`http_stream_set_server_cert`** (*audio_element_handle_t el*, **const** char **cert*)

Set SSL server certification.

**Note** EM format as string, if the client requires to verify server

**Return**

- ESP_OK on success

**Parameters**

- `el`: The http_stream element handle
- `cert`: server certification

### Structures

**`struct http_stream_event_msg_t`**

Stream event message.

### Public Members

*http_stream_event_id_t* **event_id**
Event ID

void ***http_client**
Reference to HTTP Client using by this HTTP Stream

void ***buffer**
Reference to Buffer using by the Audio Element

int **buffer_len**
Length of buffer

void ***user_data**
User data context, from `http_stream_cfg_t`

*audio_element_handle_t* **el**
Audio element context

**struct http_stream_cfg_t**
HTTP Stream configurations Default value will be used if any entry is zero.

### Public Members

*audio_stream_type_t* **type**
Type of stream

int **out_rb_size**
Size of output ringbuffer

int **task_stack**
Task stack size

int **task_core**
Task running in core (0 or 1)

int **task_prio**
Task priority (based on freeRTOS priority)

bool **stack_in_ext**
Try to allocate stack in external memory

*http_stream_event_handle_t* **event_handle**
The hook function for HTTP Stream

void ***user_data**
User data context

bool **auto_connect_next_track**
connect next track without open/close

bool **enable_playlist_parser**
Enable playlist parser

int **multi_out_num**
The number of multiple output

**const** char ***cert_pem**
SSL server certification, PEM format as string, if the client requires to verify server

esp_err_t (***crt_bundle_attach**) (void *conf)
Function pointer to esp_crt_bundle_attach. Enables the use of certification bundle for server verification, must be enabled in menuconfig

int **request_size**
Request data size each time from `http_client` Defaults use DEFAULT_ELEMENT_BUFFER_LENGTH if set to 0 Need care this setting if audio frame size is small and want low latency playback

int **request_range_size**
Range size setting for header `Range: bytes=start-end` Request full range of resource if set to 0 Range size bigger than request size is recommended

**const** char ***user_agent**
The User Agent string to send with HTTP requests

### Macros

**HTTP_STREAM_TASK_STACK**

**HTTP_STREAM_TASK_CORE**

**HTTP_STREAM_TASK_PRIO**

**HTTP_STREAM_RINGBUFFER_SIZE**

**HTTP_STREAM_CFG_DEFAULT**()

### Type Definitions

**typedef** int (***http_stream_event_handle_t**) (*http_stream_event_msg_t* *msg)

### Enumerations

**enum http_stream_event_id_t**
HTTP Stream hook type.

*Values:*

**HTTP_STREAM_PRE_REQUEST** = 0x01
The event handler will be called before HTTP Client making the connection to the server

**HTTP_STREAM_ON_REQUEST**
The event handler will be called when HTTP Client is requesting data, If the fucntion return the value (-1: ESP_FAIL), HTTP Client will be stopped If the fucntion return the value > 0, HTTP Stream will ignore the post_field If the fucntion return the value = 0, HTTP Stream continue send data from post_field (if any)

**HTTP_STREAM_ON_RESPONSE**
The event handler will be called when HTTP Client is receiving data If the fucntion return the value (-1: ESP_FAIL), HTTP Client will be stopped If the fucntion return the value > 0, HTTP Stream will ignore the read function If the fucntion return the value = 0, HTTP Stream continue read data from HTTP Server

**HTTP_STREAM_POST_REQUEST**
The event handler will be called after HTTP Client send header and body to the server, before fetching the headers

**HTTP_STREAM_FINISH_REQUEST**
The event handler will be called after HTTP Client fetch the header and ready to read HTTP body

**HTTP_STREAM_RESOLVE_ALL_TRACKS**

**HTTP_STREAM_FINISH_TRACK**

**HTTP_STREAM_FINISH_PLAYLIST**

## 2.2.4 I2S Stream

The I2S stream receives and transmits audio data through the chip's I2S, PDM, ADC, and DAC interfaces. To use the ADC and DAC functions, the chip needs to define `SOC_I2S_SUPPORTS_ADC_DAC`. The stream integrates automatic level control (ALC) to adjust volume, multi-channel output, and sending audio data with extended bit width. The relevant control bits are defined in *`i2s_stream_cfg_t`*.

### Application Example

- Reader example: recorder/pipeline_wav_amr_sdcard
- Writer example: get-started/play_mp3_control

### Header File

- audio_stream/include/i2s_stream.h

### Functions

*audio_element_handle_t* **`i2s_stream_init`**(*i2s_stream_cfg_t *config*)

Create a handle to an Audio Element to stream data from I2S to another Element or get data from other elements sent to I2S, depending on the configuration of stream type is AUDIO_STREAM_READER or AUDIO_STREAM_WRITER.

**Note** If I2S stream is enabled with built-in DAC mode, please don't use I2S_NUM_1. The built-in DAC functions are only supported on I2S0 for the current ESP32 chip.

**Return** The Audio Element handle

**Parameters**

- `config`: The configuration

esp_err_t **`i2s_stream_set_channel_type`**(*i2s_stream_cfg_t *config*, *i2s_channel_type_t type*)

Set I2S stream channel format type.

**Note** : This function only updates *i2s_stream_cfg_t*, so it needs to be called before i2s_stream_init.

**Return**

- ESP_OK
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] config`: The I2S stream configuration
- `[in] type`: I2S channel format type

esp_err_t **i2s_stream_set_clk** (*audio_element_handle_t i2s_stream*, int *rate*, int *bits*, int *ch*)
Setup clock for I2S Stream, this function is only used with handle created by `i2s_stream_init`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] i2s_stream`: The i2s element handle
- `[in] rate`: Clock rate (in Hz)
- `[in] bits`: Audio bit width (8, 16, 24, 32)
- `[in] ch`: Number of Audio channels (1: Mono, 2: Stereo). But when set to tdm mode, ch is slot mask.(ex: I2S_TDM_SLOT0 | I2S_TDM_SLOT1 | I2S_TDM_SLOT2 | I2S_TDM_SLOT3)

esp_err_t **i2s_alc_volume_set** (*audio_element_handle_t i2s_stream*, int *volume*)
Set the volume of input audio stream with ALC. Positive value indicates an increase in volume, negative value indicates a decrease in volume, 0 indicates the volume level remains unchanged.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] i2s_stream`: The i2s element handle
- `[in] volume`: The gain of input audio stream:
  - Supported range [-64, 63], unit: dB

esp_err_t **i2s_alc_volume_get** (*audio_element_handle_t i2s_stream*, int **volume*)
Get volume of stream.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] i2s_stream`: The i2s element handle
- `[in] volume`: The volume of stream

esp_err_t **i2s_stream_sync_delay** (*audio_element_handle_t i2s_stream*, int *delay_ms*)
Set sync delay of stream.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] i2s_stream`: The i2s element handle

- `[in] delay_ms`: The delay of stream

### Structures

**struct i2s_stream_cfg_t**
I2S Stream configurations Default value will be used if any entry is zero.

#### Public Members

*audio_stream_type_t* **type**
Type of stream

i2s_comm_mode_t **transmit_mode**
I2S transmit mode

i2s_chan_config_t **chan_cfg**
I2S controller channel configuration

i2s_std_config_t **std_cfg**
I2S standard mode major configuration that including clock/slot/gpio configuration

i2s_data_bit_width_t **expand_src_bits**
The source bits per sample when data expand

bool **use_alc**
It is a flag for ALC. If use ALC, the value is true. Or the value is false

int **volume**
The volume of audio input data will be set.

int **out_rb_size**
Size of output ringbuffer

int **task_stack**
Task stack size

int **task_core**
Task running in core (0 or 1)

int **task_prio**
Task priority (based on freeRTOS priority)

bool **stack_in_ext**
Try to allocate stack in external memory

int **multi_out_num**
The number of multiple output

bool **uninstall_drv**
whether uninstall the i2s driver when stream destroyed

bool **need_expand**
whether to expand i2s data

int **buffer_len**
Buffer length use for an Element. Note: when 'bits_per_sample' is 24 bit, the buffer length must be a multiple of 3. The recommended value is 3600

### Macros

**I2S_STREAM_TASK_STACK**

**I2S_STREAM_BUF_SIZE**

**I2S_STREAM_TASK_PRIO**

**I2S_STREAM_TASK_CORE**

**I2S_STREAM_RINGBUFFER_SIZE**

**I2S_STREAM_CFG_DEFAULT**()

**I2S_STREAM_CFG_DEFAULT_WITH_PARA**(port, rate, bits, stream_type)

### Enumerations

**enum i2s_channel_type_t**
*Values:*

**I2S_CHANNEL_TYPE_RIGHT_LEFT**
Separated left and right channel

**I2S_CHANNEL_TYPE_ALL_RIGHT**
Load right channel data in both two channels

**I2S_CHANNEL_TYPE_ALL_LEFT**
Load left channel data in both two channels

**I2S_CHANNEL_TYPE_ONLY_RIGHT**
Only load data in right channel (mono mode)

**I2S_CHANNEL_TYPE_ONLY_LEFT**
Only load data in left channel (mono mode)

## 2.2.5 PWM Stream

In some cost-sensitive scenarios, the audio signal is not converted by the DAC but is modulated by the PWM (pulse width modulation) and then implemented by a filter circuit. The PWM stream modulates the audio signal with the chip's PWM and sends out the processed audio. It only has the `AUDIO_STREAM_WRITER` type. Note that the digital-to-analog conversion by PWM has a lower signal-to-noise ratio.

### Application Example

- Writer example: player/pipeline_play_mp3_with_dac_or_pwm

### Header File

- audio_stream/include/pwm_stream.h

### Functions

*audio_element_handle_t* **pwm_stream_init** (*pwm_stream_cfg_t *config*)

Initialize PWM stream Only support AUDIO_STREAM_READER type.

**Return** The audio element handle

**Parameters**

- `config`: The PWM Stream configuration

esp_err_t **pwm_stream_set_clk** (*audio_element_handle_t pwm_stream*, int *rate*, int *bits*, int *ch*)

Setup clock for PWM Stream, this function is only used with handle created by `pwm_stream_init`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] pwm_stream`: The pwm element handle
- `[in] rate`: Clock rate (in Hz)
- `[in] bits`: Audio bit width (16, 32)
- `[in] ch`: Number of Audio channels (1: Mono, 2: Stereo)

### Structures

**struct audio_pwm_config_t**

PWM audio configurations.

#### Public Members

timer_group_t **tg_num**

timer group number (0 - 1)

timer_idx_t **timer_num**

timer number (0 - 1)

int **gpio_num_left**

the LEDC output gpio_num, Left channel

int **gpio_num_right**

the LEDC output gpio_num, Right channel

ledc_channel_t **ledc_channel_left**

LEDC channel (0 - 7), Corresponding to left channel

ledc_channel_t **ledc_channel_right**

LEDC channel (0 - 7), Corresponding to right channel

ledc_timer_t **ledc_timer_sel**
Select the timer source of channel (0 - 3)

ledc_timer_bit_t **duty_resolution**
ledc pwm bits

uint32_t **data_len**
ringbuffer size

**struct pwm_stream_cfg_t**
PWM Stream configurations Default value will be used if any entry is zero.

### Public Members

*audio_stream_type_t* **type**
Type of stream

*audio_pwm_config_t* **pwm_config**
driver configurations

int **out_rb_size**
Size of output ringbuffer

int **task_stack**
Task stack size

int **task_core**
Task running in core (0 or 1)

int **task_prio**
Task priority (based on freeRTOS priority)

int **buffer_len**
pwm_stream buffer length

bool **ext_stack**
Allocate stack on extern ram

## Macros

**PWM_STREAM_GPIO_NUM_LEFT**

**PWM_STREAM_GPIO_NUM_RIGHT**

**PWM_STREAM_TASK_STACK**

**PWM_STREAM_BUF_SIZE**

**PWM_STREAM_TASK_PRIO**

**PWM_STREAM_TASK_CORE**

**PWM_STREAM_RINGBUFFER_SIZE**

**PWM_CONFIG_RINGBUFFER_SIZE**

**PWM_STREAM_CFG_DEFAULT**()

### 2.2.6 Raw Stream

The raw stream is used to obtain the output data of the previous element of the connection or to provide the data for the next element of the connection. It does not create a thread. For `AUDIO_STREAM_READER`, the connection is [i2s] -> [filter] -> [raw] or [i2s] -> [codec-amr] -> [raw]. For `AUDIO_STREAM_WRITER`, the connection is [raw] ->[codec-mp3]->[i2s].

#### Application Example

- Reader example: protocols/voip
- Writer example: advanced_examples/downmix_pipeline

#### Header File

- audio_stream/include/raw_stream.h

#### Functions

*audio_element_handle_t* **`raw_stream_init`**(*raw_stream_cfg_t *cfg*)

Initialize RAW stream.

**Return** The audio element handle

**Parameters**

- `cfg`: The RAW Stream configuration

int **`raw_stream_read`**(*audio_element_handle_t pipeline*, char **buffer*, int *buf_size*)

Read data from Stream.

**Return** Number of bytes actually read.

**Parameters**

- `pipeline`: The audio pipeline handle
- `buffer`: The buffer
- `buf_size`: Maximum number of bytes to be read.

int **`raw_stream_write`**(*audio_element_handle_t pipeline*, char **buffer*, int *buf_size*)

Write data to Stream.

**Return** Number of bytes written

**Parameters**

- `pipeline`: The audio pipeline handle
- `buffer`: The buffer
- `buf_size`: Number of bytes to write

#### Structures

**struct raw_stream_cfg_t**

Raw stream provides APIs to obtain the pipeline data without output stream or fill the pipeline data without input stream. The stream has two types / modes, reader and writer:

- AUDIO_STREAM_READER, e.g. [i2s]->[filter]->[raw],[i2s]->[codec-amr]->[raw]
- AUDIO_STREAM_WRITER, e.g. [raw]->[codec-mp3]->[i2s] Raw Stream configurations

##### Public Members

*audio_stream_type_t* **type**

Type of stream

int **out_rb_size**

Size of output ringbuffer

#### Macros

**RAW_STREAM_RINGBUFFER_SIZE**

**RAW_STREAM_CFG_DEFAULT**()

### 2.2.7 SPIFFS Stream

The SPIFFS stream reads and writes audio data from or into SPIFFS.

#### Application Example

- player/pipeline_spiffs_mp3

#### Header File

- audio_stream/include/spiffs_stream.h

#### Functions

*audio_element_handle_t* **spiffs_stream_init**(*spiffs_stream_cfg_t *config*)

Create a handle to an Audio Element to stream data from SPIFFS to another Element or get data from other elements written to SPIFFS, depending on the configuration the stream type, either AUDIO_STREAM_READER or AUDIO_STREAM_WRITER.

**Return** The Audio Element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct spiffs_stream_cfg_t**
SPIFFS Stream configuration, if any entry is zero then the configuration will be set to default values.

##### Public Members

*audio_stream_type_t* **type**
Stream type

int **buf_sz**
Audio Element Buffer size

int **out_rb_size**
Size of output ringbuffer

int **task_stack**
Task stack size

int **task_core**
Task running in core (0 or 1)

int **task_prio**
Task priority (based on freeRTOS priority)

bool **write_header**
Choose to write amrnb/armwb header in spiffs whether or not (true or false, true means choose to write amrnb header)

#### Macros

**SPIFFS_STREAM_BUF_SIZE**

**SPIFFS_STREAM_TASK_STACK**

**SPIFFS_STREAM_TASK_CORE**

**SPIFFS_STREAM_TASK_PRIO**

**SPIFFS_STREAM_RINGBUFFER_SIZE**

**SPIFFS_STREAM_CFG_DEFAULT**()

### 2.2.8 TCP Client Stream

The TCP client stream reads and writes server data over TCP.

### Application Example

- get-started/pipeline_tcp_client

### Header File

- audio_stream/include/tcp_client_stream.h

### Functions

*audio_element_handle_t* **tcp_stream_init** (*tcp_stream_cfg_t* **config*)

Initialize a TCP stream to/from an audio element This function creates a TCP stream to/from an audio element depending on the stream type configuration (e.g., AUDIO_STREAM_READER or AUDIO_STREAM_WRITER). The handle of the audio element is the returned.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

### Structures

**struct tcp_stream_event_msg**

TCP Stream massage configuration.

#### Public Members

void ***source**

Element handle

void ***data**

Data of input/output

int **data_len**

Data length of input/output

esp_transport_handle_t **sock_fd**

handle of socket

**struct tcp_stream_cfg_t**

TCP Stream configuration, if any entry is zero then the configuration will be set to default values.

#### Public Members

*audio_stream_type_t* **type**

Type of stream

int **timeout_ms**

time timeout for read/write

int **port**

TCP port>

char ***host**
TCP host>

int **task_stack**
Task stack size

int **task_core**
Task running in core (0 or 1)

int **task_prio**
Task priority (based on freeRTOS priority)

bool **ext_stack**
Allocate stack on extern ram

*tcp_stream_event_handle_cb* **event_handler**
TCP stream event callback

void ***event_ctx**
User context

### Macros

**TCP_STREAM_DEFAULT_PORT**
TCP stream parameters.

**TCP_STREAM_TASK_STACK**

**TCP_STREAM_BUF_SIZE**

**TCP_STREAM_TASK_PRIO**

**TCP_STREAM_TASK_CORE**

**TCP_SERVER_DEFAULT_RESPONSE_LENGTH**

**TCP_STREAM_CFG_DEFAULT**()

### Type Definitions

**typedef struct** *tcp_stream_event_msg* **tcp_stream_event_msg_t**
TCP Stream massage configuration.

**typedef** esp_err_t (***tcp_stream_event_handle_cb**) (*tcp_stream_event_msg_t* *msg, *tcp_stream_status_t* state, void *event_ctx)

### Enumerations

**enum tcp_stream_status_t**
*Values:*

**TCP_STREAM_STATE_NONE**

**TCP_STREAM_STATE_CONNECTED**

### 2.2.9 Tone Stream

The tone stream reads the data generated by tools/audio_tone/mk_audio_tone.py. It only supports the `AUDIO_STREAM_READER` type.

#### Application Example

- player/pipeline_flash_tone

#### Header File

- audio_stream/include/tone_stream.h

#### Functions

*audio_element_handle_t* **tone_stream_init** (*tone_stream_cfg_t* **config*)

Create an Audio Element handle to stream data from flash to another Element, only support AUDIO_STREAM_READER type.

**Return** The Audio Element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct tone_stream_cfg_t**

TONE Stream configurations, if any entry is zero then the configuration will be set to default values.

##### Public Members

*audio_stream_type_t* **type**

Stream type

int **buf_sz**

Audio Element Buffer size

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

Task running in core (0 or 1)

int **task_prio**

Task priority (based on freeRTOS priority)

**const** char ***label**

Label of tone stored in flash. The default value is `flash_tone`

bool **extern_stack**

Task stack allocate on the extern ram

bool **use_delegate**
Read tone partition with esp_delegate. If task stack is on extern ram, this MUST be TRUE

### Macros

**TONE_STREAM_BUF_SIZE**

**TONE_STREAM_TASK_STACK**

**TONE_STREAM_TASK_CORE**

**TONE_STREAM_TASK_PRIO**

**TONE_STREAM_RINGBUFFER_SIZE**

**TONE_STREAM_EXT_STACK**

**TONE_STREAM_USE_DELEGATE**

**TONE_STREAM_CFG_DEFAULT**()

## 2.2.10 Flash-Embedding Stream

The flash-embedding stream reads the data generated by tools/audio_tone/mk_embed_flash.py. It only supports the `AUDIO_STREAM_READER` type.

### Application Example

- player/pipeline_embed_flash_tone

### Header File

- audio_stream/include/embed_flash_stream.h

### Functions

*audio_element_handle_t* **embed_flash_stream_init**(*embed_flash_stream_cfg_t* **config*)
Create an Audio Element handle to stream data from flash to another Element, only support AUDIO_STREAM_READER type.

**Return** The Audio Element handle

**Parameters**

- `config`: The configuration

esp_err_t **embed_flash_stream_set_context**(*audio_element_handle_t embed_stream*, **const** *embed_item_info_t* **context*, int *max_num*)
Set the embed flash context.

```
This function mainly provides information about embed flash data
```

**Return**

- ESP_OK

- ESP_FAIL

**Parameters**

- `[in] embed_stream`: The embed flash element handle
- `[in] context`: The embed flash context
- `[in] max_num`: The number of embed flash context

## Structures

**struct embed_flash_stream_cfg_t**

Flash-embedding stream configurations, if any entry is zero then the configuration will be set to default values.

### Public Members

int **buf_sz**

Audio Element Buffer size

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

Task running in core (0 or 1)

int **task_prio**

Task priority (based on freeRTOS priority)

bool **extern_stack**

At present, task stack can only be placed on `SRAM`, so it should always be set to `false`

**struct embed_item_info**

Embed tone information in flash.

### Public Members

**const** uint8_t ***address**

The corresponding address in flash

int **size**

Size of corresponding data

## Macros

**EMBED_FLASH_STREAM_BUF_SIZE**

**EMBED_FLASH_STREAM_TASK_STACK**

**EMBED_FLASH_STREAM_TASK_CORE**

**EMBED_FLASH_STREAM_TASK_PRIO**

**EMBED_FLASH_STREAM_RINGBUFFER_SIZE**

**EMBED_FLASH_STREAM_EXT_STACK**

**EMBED_FLASH_STREAM_CFG_DEFAULT**()

### Type Definitions

**typedef struct** *embed_item_info* **embed_item_info_t**

Embed tone information in flash.

## 2.2.11 TTS Stream

The tex-to-speech stream (TTS stream) obtains the `esp_tts_voice` data of esp-sr. It only supports the `AUDIO_STREAM_READER` type.

### Application Example

- Reader example: player/pipeline_tts_stream

### Header File

- audio_stream/include/tts_stream.h

### Functions

*audio_element_handle_t* **tts_stream_init**(*tts_stream_cfg_t* **config*)

Create a handle to an Audio Element to stream data from TTS to another Element, the stream type only support AUDIO_STREAM_READER for now.

**Return** The Audio Element handle

**Parameters**

- `config`: The configuration

esp_err_t **tts_stream_set_strings**(*audio_element_handle_t el*, **const** char **strings*)

Set tts stream strings.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The audio element handle
- `[in] strings`: The string pointer

esp_err_t **tts_stream_set_speed**(*audio_element_handle_t el*, *tts_voice_speed_t speed*)

Setting tts stream voice speed.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The esp_audio instance
- `[in] speed`: Speed will be set. 0-5 is legal. 0 is the slowest speed.

esp_err_t **`tts_stream_get_speed`**(*audio_element_handle_t el*, *tts_voice_speed_t *speed*)
Get tts stream voice speed.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] el`: The esp_audio instance
- `[in] speed`: Return tts stream Speed will be [0,5]

## Structures

**`struct tts_stream_cfg_t`**
TTS Stream configurations, if any entry is zero then the configuration will be set to default values.

### Public Members

*audio_stream_type_t* **`type`**
Stream type

int **`buf_sz`**
Audio Element Buffer size

int **`out_rb_size`**
Size of output ringbuffer

int **`task_stack`**
Task stack size

int **`task_core`**
Task running in core (0 or 1)

int **`task_prio`**
Task priority (based on freeRTOS priority)

bool **`ext_stack`**
Allocate stack on extern ram

### Macros

**TTS_STREAM_BUF_SIZE**

**TTS_STREAM_TASK_STACK**

**TTS_STREAM_TASK_CORE**

**TTS_STREAM_TASK_PRIO**

**TTS_STREAM_RINGBUFFER_SIZE**

**TTS_STREAM_CFG_DEFAULT**()

### Enumerations

**enum tts_voice_speed_t**

*Values:*

**TTS_VOICE_SPEED_0**

**TTS_VOICE_SPEED_1**

**TTS_VOICE_SPEED_2**

**TTS_VOICE_SPEED_3**

**TTS_VOICE_SPEED_4**

**TTS_VOICE_SPEED_5**

**TTS_VOICE_SPEED_MAX**

## 2.3 Playlist

[]

A playlist is a list of audio files that can be played back either sequentially or in a specified order.

The `sdcard_scan()` function in the playlist/include/sdcard_scan.h scans the audio files in a microSD card and generate a playlist of files. You can specify file depth and filter out file types when scanning. The playlist instances can be saved to a variety of storage media. The following are the supported storage media:

- *Saving to MicroSD Card*
- *Saving to DRAM*
- *Saving to NVS Partition in Flash*
- *Saving to DATA_UNDEFINED Partition in Flash*

After scanning the audio files, you can use the `playlist_operator_handle_t` handle to call the corresponding functions to create, save, print playlists, and obtain the path corresponding to the audio ID. Currently, most of the storage media mentioned in this document support the above functions.

See the description below for the API details.

### 2.3.1 Scanning MicroSD Card

The `sdcard_scan()` function can scan audio files in a specified path and generate playlists. It supports the scanning of files at a specified depth and filtering of file types. Then, the playlist can be saved to the specified storage medium using a callback function.

#### Application Example

- player/pipeline_sdcard_mp3_control
- cli

#### Header File

- playlist/include/sdcard_scan.h

#### Functions

esp_err_t **sdcard_scan**(*sdcard_scan_cb_t cb*, **const** char **path*, int *depth*, **const** char **file_extension*[], int *filter_num*, void **user_data*)

Scan files in SD card and use callback function to save files that meet filtering conditions.

**Note** example sdcard_scan(callback, "/sdcard", 5, const char *[]{"mp3", "aac"}, 2, user_data); Scan 5 levels folder in sdcard and save mp3 files and aac files.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `cb`: The callback function
- `path`: The path to be scanned
- `depth`: The depth of file scanning // .e.g. if you only want to save files in "/test" , depth = 0. // if you want to save files in "/test/scan_test/", depth = 1
- `file_extension`: File extension of files that are supposed to be saved // .e.g. const char *[]{"mp3", "aac"}
- `filter_num`: Number of filters
- `user_data`: The data to be used by callback function

#### Type Definitions

**typedef** void (***sdcard_scan_cb_t**)(void *user_data, char *url)

### 2.3.2 Saving Playlist

#### Saving to MicroSD Card

The playlist can be stored in the microSD card. Functions, such as those to save and display the playlist, can be called through the `playlist_operator_handle_t` handle.

#### Application Example

- player/pipeline_sdcard_mp3_control
- cli

#### Header File

- playlist/include/sdcard_list.h

#### Functions

esp_err_t **sdcard_list_create** (*playlist_operator_handle_t *handle*)

Create a playlist in sdcard by list id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `[out] handle`: The playlist handle from application layer

esp_err_t **sdcard_list_show** (*playlist_operator_handle_t handle*)

Show all the URLs in sdcard playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **sdcard_list_next** (*playlist_operator_handle_t handle*, int *step*, char ****url_buff***)

The following URLs in sdcard playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

- `step`: The offset of URL from current URL
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **sdcard_list_prev**(*playlist_operator_handle_t handle*, int *step*, char ***url_buff*)
The previous URLs in sdcard playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: The offset of URL from current URL
- `[out] url_buff`: A second rank pointer to get a address of URL

bool **sdcard_list_exist**(*playlist_operator_handle_t handle*, **const** char **url*)
Judge whether the url exists in sdcard playlist.

**Return**

- true existence
- false Non-existent

**Parameters**

- `handle`: Playlist handle
- `url`: The url to be checked

esp_err_t **sdcard_list_reset**(*playlist_operator_handle_t handle*)
Reset sdcard playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **sdcard_list_current**(*playlist_operator_handle_t handle*, char ***url_buff*)
Get current URL in sdcard playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **sdcard_list_choose** (*playlist_operator_handle_t handle*, int *url_id*, char ***url_buff*)
Choose a url by url id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url_id`: The id of url in sdcard list
- `[out] url_buff`: A second rank pointer to get a address of URL

int **sdcard_list_get_url_num** (*playlist_operator_handle_t handle*)
Get URLs number in sdcard playlist.

**Return**

- URLs number in sdcard playlist
- ESP_FAIL Fail to get number of urls

**Parameters**

- `handle`: Playlist handle

int **sdcard_list_get_url_id** (*playlist_operator_handle_t handle*)
Get current url id in the sdcard playlist.

**Return**

- Current url id in partition playlist
- ESP_FAIL Fail to get url id

**Parameters**

- `handle`: Playlist handle

esp_err_t **sdcard_list_destroy** (*playlist_operator_handle_t handle*)
Destroy sdcard playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **sdcard_list_save** (*playlist_operator_handle_t handle*, **const** char **url*)
Save URL to sdcard playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url`: URL to be saved

### Saving to DRAM

The playlist can be stored in DRAM. Functions, such as those to save and display the playlist, can be called through the `playlist_operator_handle_t` handle.

### Header File

- playlist/include/dram_list.h

### Functions

esp_err_t **dram_list_create** (*playlist_operator_handle_t *handle*)

Create a playlist in dram.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `[out] handle`: The playlist handle from application layer

esp_err_t **dram_list_save** (*playlist_operator_handle_t handle*, **const** char **url*)

Save URL to dram playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url`: URL to be saved

esp_err_t **dram_list_next** (*playlist_operator_handle_t handle*, int *step*, char ***url_buff*)

The following URLs in dram playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: The offset of URL from current URL

- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **dram_list_prev** (*playlist_operator_handle_t handle*, int *step*, char ***url_buff*)
The previous URLs in dram playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: The offset of URL from current URL
- `[out] url_buff`: A second rank pointer to get a address of URL

bool **dram_list_exist** (*playlist_operator_handle_t handle*, **const** char **url*)
Judge whether the url exists in dram playlist.

**Return**

- true existence
- false Non-existent

**Parameters**

- `handle`: Playlist handle
- `url`: The url to be checked

esp_err_t **dram_list_reset** (*playlist_operator_handle_t handle*)
Reset dram playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **dram_list_current** (*playlist_operator_handle_t handle*, char ***url_buff*)
The current URL in current playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **dram_list_choose** (*playlist_operator_handle_t handle*, int *url_id*, char ***url_buff*)
Choose a url by url id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url_id`: The id of url in dram list
- `[out] url_buff`: A second rank pointer to get a address of URL

int **dram_list_get_url_num**(*playlist_operator_handle_t handle*)
Get URLs number in the dram playlist.

**Return**

- URLs number in dram playlist
- ESP_FAIL Fail to get number of urls

**Parameters**

- `handle`: Playlist handle

int **dram_list_get_url_id**(*playlist_operator_handle_t handle*)
Get current url id in the dram playlist.

**Return**

- Current url id in dram playlist
- ESP_FAIL Fail to get url id

**Parameters**

- `handle`: Playlist handle

esp_err_t **dram_list_show**(*playlist_operator_handle_t handle*)
Show all the URLs in the dram playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **dram_list_remove_by_url**(*playlist_operator_handle_t handle*, **const** char **url*)
Remove corrsponding url in dram list.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

- `url`: The url to be removed

esp_err_t **dram_list_remove_by_url_id**(*playlist_operator_handle_t handle*, uint16_t *url_id*)
Remove url by id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url_id`: The url id to be removed

esp_err_t **dram_list_destroy**(*playlist_operator_handle_t handle*)
Destroy the dram playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

### Saving to NVS Partition in Flash

The playlist can be stored in the NVS partition in flash. Functions, such as those to save and display the playlist, can be called through the `playlist_operator_handle_t` handle.

### Header File

- playlist/include/flash_list.h

### Functions

esp_err_t **flash_list_create**(*playlist_operator_handle_t *handle*)
Create a playlist in nvs flash.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `[out] handle`: Playlist handle

esp_err_t **flash_list_save**(*playlist_operator_handle_t handle*, **const** char **url*)
Save URL to nvs flash list.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url`: URL to be saved

esp_err_t **flash_list_show** (*playlist_operator_handle_t handle*)

Show all the URLs in nvs flash list.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **flash_list_next** (*playlist_operator_handle_t handle*, int *step*, char ***url_buff*)

The following URLs in nvs flash playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: The offset of URL from current URL
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **flash_list_prev** (*playlist_operator_handle_t handle*, int *step*, char ***url_buff*)

The previous URLs in nvs flash playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: The offset of URL from current URL
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **flash_list_current** (*playlist_operator_handle_t handle*, char ***url_buff*)

The current URL in nvs flash playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `[out] url_buff`: A second rank pointer to get a address of URL

bool **`flash_list_exist`** (*playlist_operator_handle_t handle*, **`const`** char **url*)
Judge whether the url exists in flash playlist.

**Return**

- true existence
- false Non-existent

**Parameters**

- `handle`: Playlist handle
- `url`: The url to be checked

esp_err_t **`flash_list_reset`** (*playlist_operator_handle_t handle*)
Reset flash playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **`flash_list_choose`** (*playlist_operator_handle_t handle*, int *url_id*, char ***url_buff*)
Choose a url by url id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url_id`: The id of url in flash list
- `[out] url_buff`: A second rank pointer to get a address of URL

int **`flash_list_get_url_num`** (*playlist_operator_handle_t handle*)
Get URLs number in the flash playlist.

**Return**

- URLs number in flash playlist
- ESP_FAIL Fail to get number of urls

**Parameters**

- `handle`: Playlist handle

int **flash_list_get_url_id**(*playlist_operator_handle_t handle*)
Get current url id in the flash playlist.

**Return**

- Curernt url id in flash playlist
- ESP_FAIL Fail to get url id

**Parameters**

- `handle`: Playlist handle

esp_err_t **flash_list_destroy**(*playlist_operator_handle_t handle*)
Destroy the nvs flash playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

### Saving to `DATA_UNDEFINED` Partition in Flash

The playlist can be stored in the `DATA_UNDEFINED` partition (see Partition Tables for details) in flash. Functions, such as those to save and display the playlist, can be called through the `playlist_operator_handle_t` handle. Please add the two partitions whose subtypes are 0x06 and 0x07 to the flash partition table first.

### Header File

- playlist/include/partition_list.h

### Functions

esp_err_t **partition_list_create**(*playlist_operator_handle_t *handle*)
Create a playlist in flash partition by list id.

**Note** Please add 2 partitions to partition table whose subtype are 0x06 and 0x07 first

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `[out] handle`: The playlist handle from application layer

esp_err_t **partition_list_save**(*playlist_operator_handle_t handle*, **const** char **url*)
Save URL to partition playlist.

**Return**

- ESP_OK success

- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url`: URL to be saved

esp_err_t **`partition_list_next`** (*playlist_operator_handle_t handle*, int *step*, char ***url_buff*)
The following URLs in partition playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: The offset of URL from current URL
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **`partition_list_prev`** (*playlist_operator_handle_t handle*, int *step*, char ***url_buff*)
The previous URLs in partition playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: The offset of URL from current URL
- `[out] url_buff`: A second rank pointer to get a address of URL

bool **`partition_list_exist`** (*playlist_operator_handle_t handle*, **const** char **url*)
Judge whether the url exists in partition playlist.

**Return**

- true existence
- false Non-existent

**Parameters**

- `handle`: Playlist handle
- `url`: The url to be checked

esp_err_t **`partition_list_reset`** (*playlist_operator_handle_t handle*)
Reset partition playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **partition_list_current** (*playlist_operator_handle_t handle*, char ***url_buff*)
Get current URL in the partition playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **partition_list_choose** (*playlist_operator_handle_t handle*, int *url_id*, char ***url_buff*)
Choose a url by url id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url_id`: The id of url in partition list
- `[out] url_buff`: A second rank pointer to get a address of URL

int **partition_list_get_url_num** (*playlist_operator_handle_t handle*)
Get URLs number in the partition playlist.

**Return**

- URLs number in partition playlist
- ESP_FAIL Fail to get number of urls

**Parameters**

- `handle`: Playlist handle

int **partition_list_get_url_id** (*playlist_operator_handle_t handle*)
Get curernt url id in the partition playlist.

**Return**

- Current url id in partition playlist
- ESP_FAIL Fail to get url id

**Parameters**

- `handle`: Playlist handle

esp_err_t **partition_list_show** (*playlist_operator_handle_t handle*)
Show all the URLs in the partition playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **partition_list_destroy**(*playlist_operator_handle_t handle*)

Destroy the partition playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

### 2.3.3 Playlist Manager

Playlist Manager manages the above playlists and can add multiple playlist instances to the `playlist_handle_t` handle.

#### Header File

- playlist/include/playlist.h

#### Functions

*playlist_handle_t* **playlist_create**(void)

Create a playlist manager handle.

**Return**

- playlist handle success
- NULL failed

esp_err_t **playlist_add**(*playlist_handle_t handle*, *playlist_operator_handle_t list_handle*, uint8_t *list_id*)

Create a playlist manager and add playlist handle to it.

**Note** The partition playlist can only be added once, or it will be overwrited by the newest partiiton playlist

**Note** Different lists must use different IDs, because even if they are in different handles, list_id is the only indicator that distinguishes them.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist manager handle

- `list_handle`: The playlist handle to be added
- `list_id`: The playlist id to be registered

esp_err_t **playlist_checkout_by_id**(*playlist_handle_t handle*, uint8_t *id*)

Playlist checkout by list id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `id`: Specified list id

int **playlist_get_list_num**(*playlist_handle_t handle*)

Get number of playlists in the handle.

**Return**

- success Number of playlists in handle
- failed -1

**Parameters**

- `handle`: Playlist handle

*playlist_type_t* **playlist_get_current_list_type**(*playlist_handle_t handle*)

Get current playlist type.

**Return**

- success Type of current playlist
- failed -1

**Parameters**

- `handle`: Playlist handle

int **playlist_get_current_list_id**(*playlist_handle_t handle*)

Get current playlist id.

**Return**

- success Current playlist id
- failed -1

**Parameters**

- `handle`: Playlist handle

esp_err_t **playlist_get_current_list_url**(*playlist_handle_t handle*, char ***url_buff*)

Get current URL in current playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `[out] url_buff`: A second rank pointer to get a address of URL

int **playlist_get_current_list_url_num**(*playlist_handle_t handle*)
Get number of URLs in current playlist.

**Return** Number of URLS in current playlsit

**Parameters**

- `handle`: Playlist handle

int **playlist_get_current_list_url_id**(*playlist_handle_t handle*)
Get current url id in current playlist.

**Return** Current url's id in current playlsit

**Parameters**

- `handle`: Playlist handle

esp_err_t **playlist_save**(*playlist_handle_t handle*, **const** char **url*)
Save a URL to the current playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url`: The URL to be saved ot sdcard

esp_err_t **playlist_next**(*playlist_handle_t handle*, int *step*, char ***url_buff*)
Next URl in current playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: Next steps from current position
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **playlist_prev**(*playlist_handle_t handle*, int *step*, char ***url_buff*)
Previous URL in current playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `step`: Previous steps from current position
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **playlist_choose** (*playlist_handle_t handle*, int *url_id*, char ***url_buff*)

Choose a url by url id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url_id`: The id of url in current list
- `[out] url_buff`: A second rank pointer to get a address of URL

esp_err_t **playlist_show** (*playlist_handle_t handle*)

Show URLs in current playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **playlist_reset** (*playlist_handle_t handle*)

Reset current playlist.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

esp_err_t **playlist_remove_by_url** (*playlist_handle_t handle*, **const** char **url*)

Remove corresponding url.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url`: The url to be removed

esp_err_t **`playlist_remove_by_url_id`** (*playlist_handle_t handle*, uint16_t *url_id*)
Remove url by url id.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle
- `url_id`: The id of url to be removed

bool **`playlist_exist`** (*playlist_handle_t handle*, **`const`** char **url*)
Judge whether the url exists in current playlist.

**Return**

- true existence
- false Non-existent

**Parameters**

- `handle`: Playlist handle
- `url`: The url to be checked

esp_err_t **`playlist_destroy`** (*playlist_handle_t handle*)
Destroy all playlists in the handle.

**Return**

- ESP_OK success
- ESP_FAIL failed

**Parameters**

- `handle`: Playlist handle

### Structures

**`struct playlist_operation_t`**
All types of Playlists' operation.

### Public Members

esp_err_t (***show**) (void *playlist)
Show all the URLs in playlist

esp_err_t (***save**) (void *playlist, **const** char *url)
Save URLs to playlist

esp_err_t (***next**) (void *playlist, int step, char **url_buff)
Get next URL in playlist

esp_err_t (***prev**) (void *playlist, int step, char **url_buff)
Get previous URL in playlist

esp_err_t (***reset**) (void *playlist)
Reset the playlist

esp_err_t (***choose**) (void *playlist, int url_id, char **url_buff)
Get url by url id

esp_err_t (***current**) (void *playlist, char **url_buff)
Get current URL in playlist

esp_err_t (***destroy**) (void *playlist)
Destroy playlist

bool (***exist**) (void *playlist, **const** char *url)
Judge whether the url exists

int (***get_url_num**) (void *playlist)
Get number of URLS in current playlist

int (***get_url_id**) (void *playlist)
Get current url id in playlist

*playlist_type_t* **type**
Type of playlist

esp_err_t (***remove_by_url**) (void *playlist, **const** char *url)
Remove the corresponding url

esp_err_t (***remove_by_id**) (void *playlist, uint16_t url_id)
Remove url by id

**struct playlist_operator_t**
Information of playlist manager node.

### Public Members

void ***playlist**
Specific playlist's pointer

esp_err_t (***get_operation**) (*playlist_operation_t* *operation)
Function pointer to get playlists' handle

#### Type Definitions

**typedef** *playlist_operator_t* ***playlist_operator_handle_t**

**typedef struct** playlist_handle ***playlist_handle_t**

#### Enumerations

**enum playlist_type_t**

Type of playlist.

*Values:*

**PLAYLIST_UNKNOWN** = -1

Unknown type

**PLAYLIST_SDCARD**

Playlist in sdcard

**PLAYLIST_FLASH**

Playlist in nvs

**PLAYLIST_DRAM**

Playlist in ram

**PLAYLIST_PARTITION**

Playlist in partition

## 2.4 Codecs

### 2.4.1 AAC Decoder

Decode an audio data stream provided in AAC format.

#### API Reference

#### Header File

- esp-adf-libs/esp_codec/include/codec/aac_decoder.h

#### Functions

*audio_element_handle_t* **aac_decoder_init**(*aac_decoder_cfg_t* **config*)

Create an Audio Element handle to decode incoming AAC data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct aac_decoder_cfg_t**

AAC Decoder configuration.

##### Public Members

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

CPU core number (0 or 1) where decoder task in running

int **task_prio**

Task priority (based on freeRTOS priority)

bool **stack_in_ext**

Try to allocate stack in external memory

bool **plus_enable**

Dynamically enable HE-AAC (v1 v2) decoding

#### Macros

**AAC_DECODER_TASK_STACK_SIZE**

**AAC_DECODER_TASK_CORE**

**AAC_DECODER_TASK_PRIO**

**AAC_DECODER_RINGBUFFER_SIZE**

**DEFAULT_AAC_DECODER_CONFIG**()

### 2.4.2 AMR Decoder and Encoder

Decode and encode an audio data stream from / to AMR format. Encoders cover both AMR-NB and AMR-WB formats.

#### Application Examples

Implementation of this API is demonstrated in the following examples:

- player/pipeline_play_sdcard_music
- recorder/pipeline_wav_amr_sdcard

### API Reference - Decoder

#### Header File

- esp-adf-libs/esp_codec/include/codec/amr_decoder.h

#### Functions

*audio_element_handle_t* **amr_decoder_init**(*amr_decoder_cfg_t *config*)

Create an Audio Element handle to decode incoming AMR data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct amr_decoder_cfg_t**

AMR Decoder configuration.

##### Public Members

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

CPU core number (0 or 1) where decoder task in running

int **task_prio**

Task priority (based on freeRTOS priority)

bool **stack_in_ext**

Try to allocate stack in external memory

#### Macros

**AMR_DECODER_TASK_STACK_SIZE**

**AMR_DECODER_TASK_CORE**

**AMR_DECODER_TASK_PRIO**

**AMR_DECODER_RINGBUFFER_SIZE**

**DEFAULT_AMR_DECODER_CONFIG**()

### API Reference - AMR-NB Encoder

#### Header File

- esp-adf-libs/esp_codec/include/codec/amrnb_encoder.h

#### Functions

esp_err_t **amrnb_encoder_set_bitrate** (*audio_element_handle_t self*, *amrnb_encoder_bitrate_t bitrate_mode*)

Set AMRNB encoder bitrate.

**Return**

ESP_OK ESP_FAIL

**Parameters**

- `self`: Audio element handle
- `bitrate_mode`: Bitrate choose, value from amrnb_encoder_bitrate_t

*audio_element_handle_t* **amrnb_encoder_init** (*amrnb_encoder_cfg_t *config*)

Create an Audio Element handle to encode incoming AMRNB data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct amrnb_encoder_cfg_t**

AMRNB Encoder configurations.

##### Public Members

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

Task running in core (0 or 1)

int **task_prio**

Task priority (based on freeRTOS priority)

*amrnb_encoder_bitrate_t* **bitrate_mode**

AMRNB Encoder bitrate choose

bool **contain_amrnb_header**

Choose to contain amrnb header in amrnb encoder whether or not (true or false, true means choose to contain amrnb header)

bool **stack_in_ext**
Try to allocate stack in external memory

### Macros

**AMRNB_ENCODER_TASK_STACK**

**AMRNB_ENCODER_TASK_CORE**

**AMRNB_ENCODER_TASK_PRIO**

**AMRNB_ENCODER_RINGBUFFER_SIZE**

**DEFAULT_AMRNB_ENCODER_CONFIG**()

### Enumerations

**enum amrnb_encoder_bitrate_t**
Enum of AMRNB Encoder bitrate choose.

*Values:*

**AMRNB_ENC_BITRATE_UNKNOW** = -1
Invalid mode

**AMRNB_ENC_BITRATE_MR475** = 0

**AMRNB_ENC_BITRATE_MR515** = 1

**AMRNB_ENC_BITRATE_MR59** = 2

**AMRNB_ENC_BITRATE_MR67** = 3

**AMRNB_ENC_BITRATE_MR74** = 4

**AMRNB_ENC_BITRATE_MR795** = 5

**AMRNB_ENC_BITRATE_MR102** = 6

**AMRNB_ENC_BITRATE_MR122** = 7

**AMRNB_ENC_BITRATE_MRDTX** = 8

**AMRNB_ENC_BITRATE_N_MODES** = 9

### API Reference - AMR-WB Encoder

### Header File

- esp-adf-libs/esp_codec/include/codec/amrwb_encoder.h

### Functions

esp_err_t **amrwb_encoder_set_bitrate**(*audio_element_handle_t self*, *amrwb_encoder_bitrate_t bitrate_mode*)

Set AMRWB encoder bitrate.

**Return**

ESP_OK ESP_FAIL

**Parameters**

- `self`: Audio element handle
- `bitrate_mode`: Bitrate choose, value from amrwb_encoder_bitrate_t

*audio_element_handle_t* **amrwb_encoder_init**(*amrwb_encoder_cfg_t *config*)

Create an Audio Element handle to encode incoming amrwb data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

### Structures

**struct amrwb_encoder_cfg_t**

AMRWB Encoder configurations.

#### Public Members

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

Task running in core (0 or 1)

int **task_prio**

Task priority (based on freeRTOS priority)

*amrwb_encoder_bitrate_t* **bitrate_mode**

AMRWB Encoder bitrate choose

bool **contain_amrwb_header**

Choose to contain amrwb header in amrwb encoder whether or not (true or false, true means choose to contain amrwb header)

bool **stack_in_ext**

Try to allocate stack in external memory

### Macros

**AMRWB_ENCODER_TASK_STACK**

**AMRWB_ENCODER_TASK_CORE**

**AMRWB_ENCODER_TASK_PRIO**

**AMRWB_ENCODER_RINGBUFFER_SIZE**

**DEFAULT_AMRWB_ENCODER_CONFIG**()

### Enumerations

**enum amrwb_encoder_bitrate_t**

Enum of AMRWB Encoder bitrate choose.

*Values:*

**AMRWB_ENC_BITRATE_MDNONE** = -1
Invalid mode

**AMRWB_ENC_BITRATE_MD66** = 0
6.60kbps

**AMRWB_ENC_BITRATE_MD885** = 1
8.85kbps

**AMRWB_ENC_BITRATE_MD1265** = 2
12.65kbps

**AMRWB_ENC_BITRATE_MD1425** = 3
14.25kbps

**AMRWB_ENC_BITRATE_MD1585** = 4
15.85bps

**AMRWB_ENC_BITRATE_MD1825** = 5
18.25bps

**AMRWB_ENC_BITRATE_MD1985** = 6
19.85kbps

**AMRWB_ENC_BITRATE_MD2305** = 7
23.05kbps

**AMRWB_ENC_BITRATE_MD2385** = 8
23.85kbps>

**AMRWB_ENC_BITRATE_N_MODES** = 9
Invalid mode

### 2.4.3 FLAC Decoder

Decode an audio data stream provided in FLAC format.

#### API Reference

#### Header File

- esp-adf-libs/esp_codec/include/codec/flac_decoder.h

#### Functions

*audio_element_handle_t* **flac_decoder_init** (*flac_decoder_cfg_t *config*)
Create an Audio Element handle to decode incoming FLAC data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct flac_decoder_cfg_t**
FLAC Decoder configuration.

##### Public Members

int **out_rb_size**
Size of output ringbuffer

int **task_stack**
Task stack size

int **task_core**
CPU core number (0 or 1) where decoder task in running

int **task_prio**
Task priority (based on freeRTOS priority)

bool **stack_in_ext**
Try to allocate stack in external memory

#### Macros

**FLAC_DECODER_TASK_STACK_SIZE**

**FLAC_DECODER_TASK_CORE**

**FLAC_DECODER_TASK_PRIO**

**FLAC_DECODER_RINGBUFFER_SIZE**

**DEFAULT_FLAC_DECODER_CONFIG**()

### 2.4.4 MP3 Decoder

Decode an audio data stream provided in MP3 format.

#### Application Examples

Implementation of this API is demonstrated in the following examples:

- get-started/play_mp3_control
- player/pipeline_play_sdcard_music
- player/pipeline_play_mp3_with_dac_or_pwm

#### API Reference

#### Header File

- esp-adf-libs/esp_codec/include/codec/mp3_decoder.h

#### Functions

*audio_element_handle_t* **mp3_decoder_init**(*mp3_decoder_cfg_t* **config*)

Create an Audio Element handle to decode incoming MP3 data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

**const** esp_id3_info_t ***mp3_decoder_get_id3_info**(*audio_element_handle_t self*)

Get ID3 information.

**Return** esp_id3_info_t: success NULL: ID3 is not exist or memory aloocation failed.

**Parameters**

- `self`: The audio element handle

### Structures

**struct mp3_decoder_cfg_t**
Mp3 Decoder configuration.

#### Public Members

int **out_rb_size**
Size of output ringbuffer

int **task_stack**
Task stack size

int **task_core**
CPU core number (0 or 1) where decoder task in running

int **task_prio**
Task priority (based on freeRTOS priority)

bool **stack_in_ext**
Try to allocate stack in external memory

bool **id3_parse_enable**
True: parse ID3. False: Don't parse ID3

### Macros

**MP3_DECODER_TASK_STACK_SIZE**

**MP3_DECODER_TASK_CORE**

**MP3_DECODER_TASK_PRIO**

**MP3_DECODER_RINGBUFFER_SIZE**

**DEFAULT_MP3_DECODER_CONFIG**()

## 2.4.5 OGG Decoder

Decode an audio data stream provided in OGG format.

### API Reference

### Header File

- esp-adf-libs/esp_codec/include/codec/ogg_decoder.h

#### Functions

*audio_element_handle_t* **ogg_decoder_init**(*ogg_decoder_cfg_t *config*)
Create an Audio Element handle to decode incoming OGG data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct ogg_decoder_cfg_t**
OGG Decoder configuration.

##### Public Members

int **out_rb_size**
Size of output ringbuffer

int **task_stack**
Task stack size

int **task_core**
CPU core number (0 or 1) where decoder task in running

int **task_prio**
Task priority (based on freeRTOS priority)

bool **stack_in_ext**
Try to allocate stack in external memory

#### Macros

**OGG_DECODER_TASK_STACK_SIZE**

**OGG_DECODER_TASK_CORE**

**OGG_DECODER_TASK_PRIO**

**OGG_DECODER_RINGBUFFER_SIZE**

**DEFAULT_OGG_DECODER_CONFIG**()

### 2.4.6 OPUS Decoder

Decode an audio data stream provided in OPUS format.

### API Reference

#### Header File

- esp-adf-libs/esp_codec/include/codec/opus_decoder.h

#### Functions

*audio_element_handle_t* **decoder_opus_init**(*opus_decoder_cfg_t* **config*)

Create an Audio Element handle to decode incoming OPUS data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct opus_decoder_cfg_t**

OPUS Decoder configuration.

##### Public Members

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

CPU core number (0 or 1) where decoder task in running

int **task_prio**

Task priority (based on freeRTOS priority)

bool **stack_in_ext**

Try to allocate stack in external memory

#### Macros

**OPUS_DECODER_TASK_STACK_SIZE**

**OPUS_DECODER_TASK_CORE**

**OPUS_DECODER_TASK_PRIO**

**OPUS_DECODER_RINGBUFFER_SIZE**

**DEFAULT_OPUS_DECODER_CONFIG**()

### 2.4.7 WAV Decoder and Encoder

Decode and encode an audio data stream from / to WAV format.

#### Application Examples

Implementation of this API is demonstrated in the following examples:

- player/pipeline_play_sdcard_music
- recorder/pipeline_wav_amr_sdcard

#### API Reference - Decoder

#### Header File

- esp-adf-libs/esp_codec/include/codec/wav_decoder.h

#### Functions

*audio_element_handle_t* **wav_decoder_init** (*wav_decoder_cfg_t *config*)

Create an Audio Element handle to decode incoming WAV data.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

#### Structures

**struct wav_decoder_cfg_t**

brief WAV Decoder configurations

##### Public Members

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

Task running in core (0 or 1)

int **task_prio**

Task priority (based on freeRTOS priority)

bool **stack_in_ext**

Try to allocate stack in external memory

### Macros

**WAV_DECODER_TASK_STACK**

**WAV_DECODER_TASK_CORE**

**WAV_DECODER_TASK_PRIO**

**WAV_DECODER_RINGBUFFER_SIZE**

**DEFAULT_WAV_DECODER_CONFIG**()

## API Reference - Encoder

### Header File

- esp-adf-libs/esp_codec/include/codec/wav_encoder.h

### Functions

*audio_element_handle_t* **wav_encoder_init**(*wav_encoder_cfg_t* **config*)

Create a handle to an Audio Element to encode incoming data using WAV format.

**Return** The audio element handle

**Parameters**

- `config`: The configuration

### Structures

**struct wav_encoder_cfg_t**

WAV Encoder configurations.

#### Public Members

int **out_rb_size**

Size of output ringbuffer

int **task_stack**

Task stack size

int **task_core**

Task running in core (0 or 1)

int **task_prio**

Task priority (based on freeRTOS priority)

bool **stack_in_ext**

Try to allocate stack in external memory

### Macros

**WAV_ENCODER_TASK_STACK**

**WAV_ENCODER_TASK_CORE**

**WAV_ENCODER_TASK_PRIO**

**WAV_ENCODER_RINGBUFFER_SIZE**

**DEFAULT_WAV_ENCODER_CONFIG**()

## 2.5 Audio Processing

There are couple of options implemented in the ESP-ADF to modify contents of an audio stream:

- Combine contents of two audio streams using *Downmix*
- Apply ten band *Equalizer*
- Change audio sampling frequency and convert between single and two channel with *Resample Filter*
- Modify pitch and speed of the stream using *Sonic*

Please refer to description of respective APIs below.

### 2.5.1 Downmix

This API is intended for mixing of two audio files (streams), defined as the base audio file and the newcome audio file, into one output audio file.

The newcome audio file will be downmixed into the base audio file with individual gains applied to each file.

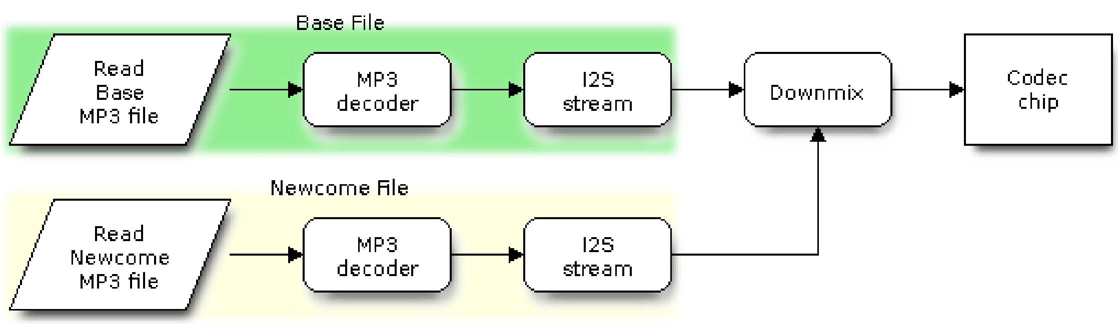


Fig. 4: Illustration of Downmixing Process

The number of channel(s) of the output audio file will be the same with that of the base audio file. The number of channel(s) of the newcome audio file will also be changed to the same with the base audio file, if it is different from that of the base audio file.

The downmix process has 3 states:

- Bypass Downmixing – Only the base audio file will be processed;

- Switch on Downmixing – The base audio file and the target audio file will first enter the transition period, during which the gains of these two files will be changed from the original level to the target level; then enter the stable period, sharing a same target gain;
- Switch off Downmixing – The base audio file and the target audio file will first enter the transition period, during which the gains of these two files will be changed back to their original levels; then enter the stable period, with their original gains, respectively. After that, the downmix process enters the bypass state.

Note that, the sample rates of the base audio file and the newcome audio file must be the same, otherwise an error occurs.

### Application Example

Implementation of this API is demonstrated in advanced_examples/downmix_pipeline example.

### API Reference

#### Header File

- esp-adf-libs/esp_codec/include/codec/downmix.h

#### Functions

void **downmix_set_input_rb_timeout** (*audio_element_handle_t self*, int *ticks_to_wait*, int *index*)

Sets the downmix timeout.

**Parameters**

- `self`: Audio element handle
- `ticks_to_wait`: Input ringbuffer timeout
- `index`: The index of multi input ringbuffer

void **downmix_set_input_rb** (*audio_element_handle_t self*, *ringbuf_handle_t rb*, int *index*)

Sets the downmix input ringbuffer. refer to `ringbuf.h`

**Parameters**

- `self`: Audio element handle
- `rb`: Handle of ringbuffer
- `index`: The index of multi input ringbuffer.

esp_err_t **downmix_set_output_type** (*audio_element_handle_t self*, esp_downmix_output_type_t *output_type*)

Set channel mode of output data. Only supported mono and dual.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `output_type`: Down-mixer output type.

esp_err_t **downmix_set_work_mode** (*audio_element_handle_t self*, esp_downmix_work_mode_t *mode*)
Sets BYPASS, ON or OFF status of down-mixer.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `mode`: Down-mixer work mode.

esp_err_t **downmix_set_out_ctx_info** (*audio_element_handle_t self*, esp_downmix_out_ctx_type_t *out_ctx*)
Passes content of per channel output stream by down-mixer.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `out_ctx`: Content of output stream.

esp_err_t **downmix_set_source_stream_info** (*audio_element_handle_t self*, int *rate*, int *ch*, int *index*)
Sets the sample rate and the number of channels of input stream to be processed.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `rate`: Sample rate of the input stream
- `ch`: Channel number of the input stream. Only supported mono and dual.
- `index`: The index of input stream. The index must be in [0, SOURCE_NUM_MAX - 1] range.

esp_err_t **downmix_set_gain_info** (*audio_element_handle_t self*, float **gain*, int *index*)
Sets the audio gain to be processed.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `gain`: The gain array of downmix which the array size is 2 and the gain data range is [-100, 100], unit: dB.
- `index`: The index of input stream. The index must be in [0, SOURCE_NUM_MAX - 1] range.

esp_err_t **downmix_set_transit_time_info** (*audio_element_handle_t self*, int *transit_time*, int *index*)
Sets the audio `transit_time` to be processed.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `transit_time`: The reset value of `transit_time`
- `index`: The index of input stream. The index must be in [0, SOURCE_NUM_MAX - 1] range

esp_err_t **source_info_init** (*audio_element_handle_t self*, esp_downmix_input_info_t **source_info*)
Initializes information of the source streams for downmixing.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `source_info`: The information array of source streams

*audio_element_handle_t* **downmix_init** (*downmix_cfg_t *config*)
Initializes the Audio Element handle for downmixing.

**Return** The audio element handler

**Parameters**

- `config`: the configuration

### Structures

**struct downmix_cfg_t**
Downmix configuration.

#### Public Members

esp_downmix_info_t **downmix_info**
Downmix information

int **max_sample**
The number of samples per downmix processing

int **out_rb_size**
Size of ring buffer

int **task_stack**
Size of task stack

int **task_core**
Task running in core…

int **task_prio**
Task priority (based on the FreeRTOS priority)

bool **stack_in_ext**
Try to allocate stack in external memory

### Macros

**DOWNMIX_TASK_STACK**

**DOWNMIX_TASK_CORE**

**DOWNMIX_TASK_PRIO**

**DOWNMIX_RINGBUFFER_SIZE**

**DM_BUF_SIZE**

**DEFAULT_DOWNMIX_CONFIG**()

## 2.5.2 Equalizer

Provided in this API equalizer supports:

- fixed number of ten (10) bands;
- four sample rates: 11025 Hz, 22050 Hz, 44100 Hz and 48000 Hz.

The center frequencies of bands are shown in table below.

| Band Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Frequency | 31 Hz | 62 Hz | 125 Hz | 250 Hz | 500 Hz | 1 kHz | 2 kHz | 4 kHz | 8 kHz | 16 kHz |

Default gain of each band is -13 dB. To set the gains of all bands use structure *equalizer_cfg*. To set the gain of individual band use function *equalizer_set_gain_info()*.

### Application Example

Implementation of this API is demonstrated in the audio_processing/pipeline_equalizer example.

### API Reference

### Header File

- esp-adf-libs/esp_codec/include/codec/equalizer.h

### Functions

esp_err_t **equalizer_set_info**(*audio_element_handle_t self*, int *rate*, int *ch*)

Set the audio sample rate and the number of channels to be processed by the equalizer.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `rate`: Audio sample rate
- `ch`: Audio channel

esp_err_t **equalizer_set_gain_info**(*audio_element_handle_t self*, int *index*, int *value_gain*, bool *is_channels_gain_equal*)

Set the audio gain to be processed by the equalizer.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `index`: The position of center frequencies of equalizer. If channel is mono, the index range is [0, 9]; If channel is stereo and `is_channels_gain_equal` is true, the index range is [0, 9]; If channel is stereo and `is_channels_gain_equal` is false, the index range is [0, 19];
- `value_gain`: The value of audio gain which in `index`
- `is_channels_gain_equal`: If audio channel is stereo, the audio gain values of two channels are equal when `is_channels_gain_equal` is `true`, otherwise it means unequal.

*audio_element_handle_t* **equalizer_init**(*equalizer_cfg_t *config*)

Create an Audio Element handle that equalizes incoming data.

**Return** The audio element handler

**Parameters**

- `config`: The configuration

### Structures

**struct equalizer_cfg**

Equalizer Configuration.

+——————————————————— + | MONO | +——————————————————+
| Only Left channel/Only Right channel | +——————————————————+
|band0|band1|band2|band3|band4|band5|band6|band7|band8|band9| +——————————————————————+
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +——————————————————+

**Note** 1) This figure indicate the default eq gain of every band in current equalizer. 2) Every channel have 10 band to set.

+——————————————————+——————————————————+ | DUAL |
+——————————————————+——————————————————+ | Left channel
| Right channel | +——————————————————+——————————————————+
|band0|band1|band2|band3|band4|band5|band6|band7|band8|band9|band0|band1|band2|band3|band4|band5|band6|band7|band8|ban
+——————————————————+——————————————————+
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
+——————————————————+——————————————————+

3) Different sample rates support different EQ frequency bands. 11025: {31, 62, 125, 250, 500, 1000, 2000, 3000, 4000, 5500} 22050: {31, 62, 125, 250, 500, 1000, 2000, 4000, 8000, 11000} 44100/48000: {31, 62, 125, 250, 500, 1000, 2000, 4000, 8000, 16000}

#### Public Members

int **samplerate**

Audio sample rate. Supported samplerate: 11025, 22050, 44100, 48000, unit: Hz

int **channel**

Number of audio channels. Supported channel: mono, stereo

int ***set_gain**

Equalizer gain

int **out_rb_size**

Size of output ring buffer

int **task_stack**

Task stack size

int **task_core**

Task running in core…

int **task_prio**

Task priority

bool **stack_in_ext**

Try to allocate stack in external memory

### Macros

**EQUALIZER_TASK_STACK**

**EQUALIZER_TASK_CORE**

**EQUALIZER_TASK_PRIO**

**EQUALIZER_RINGBUFFER_SIZE**

**DEFAULT_EQUALIZER_CONFIG**()

### Type Definitions

**typedef struct** *equalizer_cfg* **equalizer_cfg_t**

Equalizer Configuration.

+———————————————————— + | MONO | +————————————————————+ | Only Left channel/Only Right channel | +————————————————————+ |band0|band1|band2|band3|band4|band5|band6|band7|band8|band9| +————————————————————+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +————————————————————+

**Note** 1) This figure indicate the default eq gain of every band in current equalizer. 2) Every channel have 10 band to set.

+————————————————————+————————————————————+ | DUAL | +————————————————————+————————————————————+ | Left channel | Right channel | +————————————————————+————————————————————+ |band0|band1|band2|band3|band4|band5|band6|band7|band8|band9|band0|band1|band2|band3|band4|band5|band6|band7|band8|ban +————————————————————+————————————————————+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | +————————————————————+————————————————————+

3) Different sample rates support different EQ frequency bands. 11025: {31, 62, 125, 250, 500, 1000, 2000, 3000, 4000, 5500} 22050: {31, 62, 125, 250, 500, 1000, 2000, 4000, 8000, 11000} 44100/48000: {31, 62, 125, 250, 500, 1000, 2000, 4000, 8000, 16000}

## 2.5.3 Resample Filter

The Resample Filter is an *Audio Element* designed to downsample or upsample the incoming data stream as well as to convert the data between stereo and mono.

### Application Example

Implementation of this API is demonstrated in the following examples:

- audio_processing/pipeline_resample
- audio_processing/pipeline_spiffs_amr_resample
- get-started/play_mp3_control

### API Reference

### Header File

- esp-adf-libs/esp_codec/include/codec/filter_resample.h

### Functions

esp_err_t **rsp_filter_set_src_info**(*audio_element_handle_t self*, int *src_rate*, int *src_ch*)

Set the source audio sample rate and the number of channels to be processed by the resample. If need change bits or not ensure source data infomation, please use rsp_filter_change_src_info to instead this function.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `src_rate`: The sample rate of stream data
- `src_ch`: The number channels of stream data

esp_err_t **rsp_filter_change_src_info**(*audio_element_handle_t self*, int *src_rate*, int *src_ch*, int *src_bit*)

Set the source audio sample rate, the number of channels and bits per sample to be processed by the resample.

**Return**

- ESP_OK on success
- ESP_ERR_INVALID_ARG invalid arguments

**Parameters**

- `self`: Audio element handle
- `src_rate`: The sample rate of stream data
- `src_ch`: The number channels of stream data
- `src_bit`: The bit per sample of stream data

*audio_element_handle_t* **rsp_filter_init**(*rsp_filter_cfg_t *config*)

Create an Audio Element handle to resample incoming data.

```
   Depending on configuration, there are upsampling, downsampling, as well as
   converting data between mono and dual.

   - If the esp_resample_mode_t is `RESAMPLE_DECODE_MODE`, `src_rate` and `src_
↪ch` will be fetched from `audio_element_getinfo`.
   - If the esp_resample_mode_t is `RESAMPLE_ENCODE_MODE`, `src_rate`, `src_ch`,␣
↪`dest_rate` and `dest_ch` must be configured.
```

**Return** The audio element handler

**Parameters**

- `config`: The configuration

### Structures

**struct rsp_filter_cfg_t**
Resample Filter Configuration.

#### Public Members

int **src_rate**
The sampling rate of the source PCM file (in Hz)

int **src_ch**
The number of channel(s) of the source PCM file (Mono=1, Dual=2)

int **dest_rate**
The sampling rate of the destination PCM file (in Hz)

int **dest_bits**
The bit for sample of the destination PCM data. Currently, supported bit width :16 bits.

int **dest_ch**
The number of channel(s) of the destination PCM file (Mono=1, Dual=2)

int **src_bits**
The bit for sample of the source PCM data. Currently, supported bit width :8bits 16 bits 24bits 32bits.

esp_resample_mode_t **mode**
The resampling mode (the encoding mode or the decoding mode). For decoding mode, input PCM length is constant; for encoding mode, output PCM length is constant.

int **max_indata_bytes**
The maximum buffer size of the input PCM (in bytes)

int **out_len_bytes**
The buffer length of the output stream data. This parameter must be configured in encoding mode.

esp_resample_type_t **type**
The resampling type (Automatic, Upsampling and Downsampling)

int **complexity**
Indicates the complexity of the resampling. This parameter is only valid when a FIR filter is used. Range:[1, 5]; 1 indicates the lowest complexity, which means the accuracy is the lowest and the speed is the fastest; Meanwhile, 5 indicates the highest complexity, which means the accuracy is the highest and the speed is the slowest.If user set `complexity` less than 1, `complexity` can be set 1. If user set `complexity` more than 5, `complexity` can be set 5.

int **down_ch_idx**
Indicates the channel that is selected (the right channel or the left channel). This parameter is only valid when the complexity parameter is set to 0 and the number of channel(s) of the input file has changed from dual to mono.

esp_rsp_prefer_type_t **prefer_flag**
The select flag about lesser CPU usage or lower INRAM usage, refer to esp_resample.h

int **out_rb_size**
Output ringbuffer size

int **task_stack**
Task stack size

int **task_core**
Task running on core

int **task_prio**
Task priority

bool **stack_in_ext**
Try to allocate stack in external memory

#### Macros

**RSP_FILTER_BUFFER_BYTE**

**RSP_FILTER_TASK_STACK**

**RSP_FILTER_TASK_CORE**

**RSP_FILTER_TASK_PRIO**

**RSP_FILTER_RINGBUFFER_SIZE**

**DEFAULT_RESAMPLE_FILTER_CONFIG**()

### 2.5.4 Sonic

The Sonic component acts as a multidimensional filter that lets you adjust audio parameters of a WAV stream. This functionality may be useful to e.g. increase playback speed of an audio recording by a user selectable rate.

The following parameters can be adjusted:

- speed
- pitch
- interpolation type

The adjustments of the first two parameters are represented by *float* values that provide the rate of adjustment. For example, to increase the speed of an audio sample by 2 times, call `sonic_set_pitch_and_speed_info(el, 1.0, 2.0)`. To keep the speed as it is, call `sonic_set_pitch_and_speed_info(el, 1.0, 1.0)`.

For the *interpolation type* you may select either faster but less accurate linear interpolation, or slower but more accurate FIR interpolation.

#### Application Example

Implementation of this API is demonstrated in audio_processing/pipeline_sonic example.

### API Reference

#### Header File

- esp-adf-libs/esp_codec/include/codec/audio_sonic.h

#### Functions

esp_err_t **sonic_set_info**(*audio_element_handle_t self*, int *rate*, int *ch*)
: Sets the audio sample rate and the number of channels to be processed by the sonic.

  **Return**

  - ESP_OK on success
  - ESP_ERR_INVALID_ARG invalid arguments

  **Parameters**

  - `self`: Audio element handle
  - `rate`: The sample rate of stream data
  - `ch`: The channel numbers of stream data

esp_err_t **sonic_set_pitch_and_speed_info**(*audio_element_handle_t self*, float *pitch*, float *speed*)
: Sets the audio pitch and speed to be processed by the sonic.

  **Return**

  - ESP_OK on success
  - ESP_ERR_INVALID_ARG invalid arguments

  **Parameters**

  - `self`: Audio element handle
  - `pitch`: Scale factor of pitch of audio file. 0 means the original pitch. The range is [0.2 4.0].
  - `speed`: Scale factor of speed of audio file. 0 means the original speed. The range is [0.1 8.0].

*audio_element_handle_t* **sonic_init**(*sonic_cfg_t *config*)
: Creates an Audio Element handle for sonic.

  **Return** The audio element handler

  **Parameters**

  - `config`: The sonic configuration

### Structures

**struct sonic_info_t**
Information on audio file and configuration parameters required by sonic to process the file.

#### Public Members

int **samplerate**
Audio file sample rate (in Hz)

int **channel**
Number of audio file channels (Mono=1, Dual=2)

int **resample_linear_interpolate**
Flag of using simple linear interpolation. 1 indicates using simple linear interpolation. 0 indicates not using simple linear interpolation.

float **pitch**
Scale factor of pitch of audio file. If the value of 'pitch' is 0.3, the pitch of audio file processed by sonic islower than the original. If the value of 'pitch' is 1.3, the pitch of audio file processed by sonic is 30% higher than the original.

float **speed**
Scale factor of speed of audio file. If the value of 'speed' is 0.3, the speed of audio file processed by sonic is 70% slower than the original. If the value of 'speed' is 1.3, the speed of audio file processed by sonic is 30% faster than the original.

**struct sonic_cfg_t**
Sonic configuration.

#### Public Members

*sonic_info_t* **sonic_info**
Information of sonic

int **out_rb_size**
Size of output ring buffer

int **task_stack**
Task stack size

int **task_core**
Task running in core

int **task_prio**
Task priority

bool **stack_in_ext**
Try to allocate stack in external memory

### Macros

**SONIC_SET_VALUE_FOR_INITIALIZATION**

**SONIC_TASK_STACK**

**SONIC_TASK_CORE**

**SONIC_TASK_PRIO**

**SONIC_RINGBUFFER_SIZE**

**DEFAULT_SONIC_CONFIG**()

## 2.6 Services

[]

A service is a software implementation of specific product functions, such as input keys, network configuration management, and battery check. Each service is also an abstraction of hardware. For example, the input key service supports ADC keys and GPIO keys. Services can be reused on different products, and high-level APIs and events allow easy and convenient product development.

For details please refer to descriptions listed below.

### 2.6.1 Bluetooth Service

[]

The Bluetooth service is dedicated to interface with Bluetooth devices and provides support for the following protocols:

- HFP (Hands-Free Profile): remotely controlling the mobile phone by the Hands-Free device and the voice connections between them
- A2DP (Advanced Audio Distribution Profile): implementing streaming of multimedia audio using a Bluetooth connection
- AVRCP (Audio Video Remote Control Profile): used together with A2DP for remote control of devices such as headphones, car audio systems, or speakers

#### Application Example

Implementation of this API is demonstrated in the following example:

- player/pipeline_bt_sink

### Header File

- bluetooth_service/include/bluetooth_service.h

### Functions

esp_err_t **bluetooth_service_start** (*bluetooth_service_cfg_t *config*)

Initialize and start the Bluetooth service. This function can only be called for one time, and `bluetooth_service_destroy` must be called after use.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `config`: The configuration

*audio_element_handle_t* **bluetooth_service_create_stream** ()

Create Bluetooth stream, it is valid when Bluetooth service has started. The returned audio stream compatible with existing audio streams and can be used with the Audio Pipeline.

**Return** The Audio Element handle

*esp_periph_handle_t* **bluetooth_service_create_periph** ()

Create Bluetooth peripheral, it is valid when Bluetooth service has started. The returned bluetooth peripheral compatible with existing peripherals and can be used with the ESP Peripherals.

**Return** The Peripheral handle

esp_err_t **periph_bluetooth_play** (*esp_periph_handle_t periph*)

Send the AVRC passthrough command (PLAY) to the Bluetooth device.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_pause** (*esp_periph_handle_t periph*)

Send the AVRC passthrough command (PAUSE) to the Bluetooth device.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_stop** (*esp_periph_handle_t periph*)
Send the AVRC passthrough command (STOP) to the Bluetooth device.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_next** (*esp_periph_handle_t periph*)
Send the AVRC passthrough command (NEXT) to the Bluetooth device.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_prev** (*esp_periph_handle_t periph*)
Send the AVRC passthrough command (PREV) to the Bluetooth device.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_rewind** (*esp_periph_handle_t periph*)
Send the AVRC passthrough command (REWIND) to the Bluetooth device.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_fast_forward** (*esp_periph_handle_t periph*)
Send the AVRC passthrough command (FAST FORWARD) to the Bluetooth device.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_discover** (*esp_periph_handle_t periph*)
Start device discovery.

**Return**

- ESP_OK : Succeed
- ESP_ERR_INVALID_STATE: if bluetooth stack is not yet enabled
- ESP_ERR_INVALID_ARG: if invalid parameters are provided
- ESP_FAIL: others

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_cancel_discover** (*esp_periph_handle_t periph*)
Cancel device discovery.

**Return**

- ESP_OK : Succeed
- ESP_ERR_INVALID_STATE: if bluetooth stack is not yet enabled
- ESP_FAIL: others

**Parameters**

- `[in] periph`: The periph

esp_err_t **periph_bluetooth_connect** (*esp_periph_handle_t periph*, *bluetooth_addr_t remote_bda*)
Connect remote Device.

**Return**

- ESP_OK : Succeed
- ESP_ERR_INVALID_STATE: if bluetooth stack is not yet enabled
- ESP_FAIL: others

**Parameters**

- `[in] periph`: The periph
- `[in] remote_bda`: remote Bluetooth device address

esp_err_t **bluetooth_service_destroy** ()
Destroy and cleanup bluetooth service, this function must be called after destroying the Bluetoth Stream and Bluetooth Peripheral created by `bluetooth_service_create_stream` and `bluetooth_service_create_periph`

**Return**

- ESP_OK
- ESP_FAIL

int **periph_bluetooth_get_a2dp_sample_rate** ()
Get a2dp sample rate.

**Return**

- sample rate

### Structures

**struct bluetooth_service_user_cb_t**

brief Bluetooth service user callback

#### Public Members

esp_a2d_cb_t **user_a2d_cb**

callback for a2dp

esp_a2d_sink_data_cb_t **user_a2d_sink_data_cb**

callback for a2dp sink data

esp_a2d_source_data_cb_t **user_a2d_source_data_cb**

callback for a2dp source data

esp_avrc_ct_cb_t **user_avrc_ct_cb**

callback for avrc ct

**struct bluetooth_service_cfg_t**

brief Bluetooth service configuration

#### Public Members

**const** char ***device_name**

Bluetooth local device name

**const** char ***remote_name**

Bluetooth remote device name

*bluetooth_service_mode_t* **mode**

Bluetooth working mode

*bluetooth_service_user_cb_t* **user_callback**

Bluetooth user callback

### Macros

**ESP_A2DP_SAMPLE_RATE**

**BLUETOOTH_ADDR_LEN**

brief Bluetooth address length

#### Type Definitions

**typedef** uint8_t **bluetooth_addr_t**[**BLUETOOTH_ADDR_LEN**]
brief Bluetooth device address

#### Enumerations

**enum bluetooth_service_mode_t**
brief Bluetooth service working mode

*Values:*

**BLUETOOTH_A2DP_SINK**
A2DP Bluetooth sink audio, ESP32 will receive audio data from other bluetooth devices

**BLUETOOTH_A2DP_SOURCE**
A2DP Bluetooth source audio, ESP32 can send audio data to other bluetooth devices

#### Header File

- bluetooth_service/include/bt_keycontrol.h

#### Header File

- bluetooth_service/include/hfp_stream.h

#### Header File

- bluetooth_service/include/a2dp_stream.h

### 2.6.2 Input Key Service

[]

The input key service provides GPIO input interrupts and ADC key functions in the form of events. For what common key functions are defined by the events for audio products, see `input_key_user_id_t`.

#### Application Example

Implementation of this API is demonstrated in the following example:

- checks/check_board_buttons
- player/pipeline_sdcard_mp3_control
- protocols/voip

### Header File

- input_key_service/include/input_key_service.h

### Functions

*periph_service_handle_t* **input_key_service_create** (*input_key_service_cfg_t *input_key_config*)
Initialize and start the input key service.

**Return** NULL failed others input key service handle

**Parameters**

- `input_key_config`: Configuration of input key service

*periph_service_state_t* **get_input_key_service_state** (*periph_service_handle_t input_handle*)
Get the state of input key service.

**Return** state of input key service

**Parameters**

- `input_handle`: The handle of input key service

esp_err_t **input_key_service_add_key** (*periph_service_handle_t input_key_handle*, *input_key_service_info_t *input_key_info*, int *add_key_num*)
Add input key's information to service list.

**Return** ESP_OK success ESP_FAIL failed

**Parameters**

- `input_key_handle`: handle of service
- `input_key_info`: input key's information
- `add_key_num`: number of keys

### Structures

**struct input_key_service_info_t**
input key's infomation

#### Public Members

*esp_periph_id_t* **type**
ID of peripherals

int **user_id**
The key's user id

int **act_id**
The key's action id

**struct input_key_service_cfg_t**
input key's configuration

### Public Members

*periph_service_config_t* **based_cfg**
Peripheral service configuration

*esp_periph_set_handle_t* **handle**
Peripheral set handle

## Macros

**INPUT_KEY_SERVICE_TASK_STACK_SIZE**

**INPUT_KEY_SERVICE_TASK_PRIORITY**

**INPUT_KEY_SERVICE_TASK_ON_CORE**

**INPUT_KEY_SERVICE_DEFAULT_CONFIG**()

## Enumerations

**enum input_key_service_action_id_t**
input key action id

*Values:*

**INPUT_KEY_SERVICE_ACTION_UNKNOWN** = 0
unknown action id

**INPUT_KEY_SERVICE_ACTION_CLICK**
click action id

**INPUT_KEY_SERVICE_ACTION_CLICK_RELEASE**
click release action id

**INPUT_KEY_SERVICE_ACTION_PRESS**
long press action id

**INPUT_KEY_SERVICE_ACTION_PRESS_RELEASE**
long press release id

## Header File

- input_key_service/include/input_key_com_user_id.h

## Enumerations

**enum input_key_user_id_t**
input key user user-defined id

*Values:*

**INPUT_KEY_USER_ID_UNKNOWN** = -1
unknown user id

**INPUT_KEY_USER_ID_REC** = 0x01
user id for recording

**INPUT_KEY_USER_ID_SET** = 0x02
user id for settings

**INPUT_KEY_USER_ID_PLAY** = 0x03
user id for playing

**INPUT_KEY_USER_ID_MODE** = 0x04
user id for mode

**INPUT_KEY_USER_ID_VOLDOWN** = 0x05
user id for volume down

**INPUT_KEY_USER_ID_VOLUP** = 0x06
user id for volume up

**INPUT_KEY_USER_ID_MUTE** = 0x07
user id for mute

**INPUT_KEY_USER_ID_CAPTURE** = 0x08
user id for capture photo

**INPUT_KEY_USER_ID_MSG** = 0x09
user id for message

**INPUT_KEY_USER_ID_BATTERY_CHARGING** = 0x0A
user id for battery charging

**INPUT_KEY_USER_ID_WAKEUP** = 0x0B
user id for GPIO wakeup

**INPUT_KEY_USER_ID_COLOR** = 0x0C
user id for color

**INPUT_KEY_USER_ID_MAX** = 0x101

## 2.6.3 Wi-Fi Service

[]

The Wi-Fi service can configure and manage the network. SmartConfig, BluFi, and AirKiss are supported for network configuration.

### Application Example

Implementation of this API is demonstrated in the following example:

- dueros

### Header File

- wifi_service/include/wifi_service.h

### Functions

*periph_service_handle_t* **wifi_service_create**(*wifi_service_config_t *config*)

esp_err_t **wifi_service_destroy**(*periph_service_handle_t handle*)

esp_err_t **wifi_service_register_setting_handle**(*periph_service_handle_t handle*, *esp_wifi_setting_handle_t setting*, int **out_index*)

esp_err_t **wifi_service_setting_start**(*periph_service_handle_t handle*, int *index*)

esp_err_t **wifi_service_update_sta_info**(*periph_service_handle_t handle*, wifi_config_t **wifi_conf*)

esp_err_t **wifi_service_setting_stop**(*periph_service_handle_t handle*, int *index*)

esp_err_t **wifi_service_connect**(*periph_service_handle_t handle*)

esp_err_t **wifi_service_disconnect**(*periph_service_handle_t handle*)

esp_err_t **wifi_service_set_sta_info**(*periph_service_handle_t handle*, wifi_config_t **info*)

*periph_service_state_t* **wifi_service_state_get**(*periph_service_handle_t handle*)

*wifi_service_disconnect_reason_t* **wifi_service_disconnect_reason_get**(*periph_service_handle_t handle*)

esp_err_t **wifi_service_erase_ssid_manager_info**(*periph_service_handle_t handle*)

esp_err_t **wifi_service_get_last_ssid_cfg**(*periph_service_handle_t handle*, wifi_config_t **wifi_cfg*)

### Structures

**struct wifi_service_config_t**

WiFi service configurations.

#### Public Members

int **task_stack**

>0 Service task stack; =0 with out task created

int **task_prio**

Service task priority (based on freeRTOS priority)

int **task_core**

Service task running in core (0 or 1)

bool **extern_stack**

Task stack allocate on the extern ram

*periph_service_cb* **evt_cb**

Service callback function

void ***cb_ctx**

Callback context

char ***user_data**

User data

int **setting_timeout_s**
Timeout of setting WiFi

int **max_retry_time**
Maximum times of reconnection

int **max_prov_retry_time**
Maximum times of reconnection after wifi provision

uint8_t **max_ssid_num**
Maximum ssid that can be stored

### Macros

**WIFI_SERVICE_DEFAULT_CONFIG**()

### Enumerations

**enum wifi_service_event_t**
WiFi STA service status.

*Values:*

**WIFI_SERV_EVENT_UNKNOWN**

**WIFI_SERV_EVENT_CONNECTING**

**WIFI_SERV_EVENT_CONNECTED**

**WIFI_SERV_EVENT_DISCONNECTED**

**WIFI_SERV_EVENT_SETTING_TIMEOUT**

**WIFI_SERV_EVENT_SETTING_FAILED**

**WIFI_SERV_EVENT_SETTING_FINISHED**

**enum wifi_service_disconnect_reason_t**
WiFi STA disconnection reasons.

*Values:*

**WIFI_SERV_STA_UNKNOWN**

**WIFI_SERV_STA_COM_ERROR**

**WIFI_SERV_STA_AUTH_ERROR**

**WIFI_SERV_STA_AP_NOT_FOUND**

**WIFI_SERV_STA_BY_USER**

**WIFI_SERV_STA_SET_INFO**

### Header File

- wifi_service/include/esp_wifi_setting.h

### Functions

*esp_wifi_setting_handle_t* **esp_wifi_setting_create** (**const** char **tag*)

brief Create wifi setting handle instance

**Return**

- NULL, Fail
- Others, Success

**Parameters**

- `tag`: Tag of the wifi setting handle

esp_err_t **esp_wifi_setting_destroy** (*esp_wifi_setting_handle_t handle*)

brief Destroy wifi setting handle instance

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: The wifi setting handle instance

esp_err_t **esp_wifi_setting_register_function** (*esp_wifi_setting_handle_t handle*, *wifi_setting_func start*, *wifi_setting_func stop*, *wifi_setting_teardown_func teardown*)

Register the wifi setting execute functions.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: The wifi setting handle instance
- `start`: The start wifi setting
- `stop`: The stop
- `teardown`: The destroy

esp_err_t **esp_wifi_setting_register_notify_handle** (*esp_wifi_setting_handle_t handle*, void **on_handle*)

Register the notify execute handle.

**Return**

- ESP_OK

- ESP_FAIL

**Parameters**

- `handle`: The peripheral handle
- `on_handle`: The notify execute handle

esp_err_t **esp_wifi_setting_info_notify** (*esp_wifi_setting_handle_t handle*, wifi_config_t **info*)

Call this to notify the `wifi_config_t` to `on_handle`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: The wifi setting handle instance
- `info`: The `wifi_config_t`

esp_err_t **esp_wifi_setting_set_data** (*esp_wifi_setting_handle_t handle*, void **data*)

Set the user data.

**Note** Make sure the `data` lifetime is sufficient, this function does not copy all data, it only stores the data pointer

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] handle`: The wifi setting handle instance
- `data`: The user data

void ***esp_wifi_setting_get_data** (*esp_wifi_setting_handle_t handle*)

Get the user data stored on `handle`

**Return** user data pointer

**Parameters**

- `[in] handle`: The wifi setting handle instance

esp_err_t **esp_wifi_setting_start** (*esp_wifi_setting_handle_t handle*)

Call this to execute `start` function of wifi setting instance.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: The wifi setting handle instance esp_err_t **esp_wifi_setting_stop** (*esp_wifi_setting_handle_t handle*)

Call this to execute `stop` function of wifi setting instance.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: The wifi setting handle instance

esp_err_t **esp_wifi_setting_teardown** (*esp_wifi_setting_handle_t handle*, wifi_config_t **info*)

Call this to execute `teardown` function of wifi setting instance.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: The wifi setting handle instance
- `info`: The `wifi_config_t`

### Type Definitions

**typedef struct** esp_wifi_setting ***esp_wifi_setting_handle_t**

**typedef** esp_err_t (***wifi_setting_func**) (*esp_wifi_setting_handle_t* handle)

**typedef** esp_err_t (***wifi_setting_teardown_func**) (*esp_wifi_setting_handle_t* handle, wifi_config_t *info)

### Header File

- wifi_service/include/smart_config.h

### Functions

*esp_wifi_setting_handle_t* **smart_config_create** (*smart_config_info_t *info*)

brief Create smartconfig setting handle instance

**Return**

- NULL, Fail
- Others, Success

**Parameters**

- `info`: Configuration of the smartconfig

### Structures

**struct smart_config_info_t**
esp smartconfig configuration

#### Public Members

smartconfig_type_t **type**
Type of smartconfig

### Macros

**SMART_CONFIG_INFO_DEFAULT**()

### Header File

- wifi_service/include/blufi_config.h

### Functions

*esp_wifi_setting_handle_t* **blufi_config_create**(void **info*)
Create blufi setting handle instance.

**Return**

- NULL, Fail
- Others, Success

**Parameters**

- `[in] info`: A pointer to void

esp_err_t **blufi_set_sta_connected_flag**(*esp_wifi_setting_handle_t handle*, bool *flag*)
Set flag to judge whether the station has connected to the AP.

**Return**

- NULL, Fail
- Others, Success

**Parameters**

- `[in] handle`: Wifi setting handle
- `[in] flag`: bool type of station connection state

esp_err_t **blufi_set_customized_data**(*esp_wifi_setting_handle_t handle*, char **data*, int *data_len*)
Set customized data to be sent after configurate wifi successfully.

**Return**

- ESP_FAIL, Fail

- ESP_OK, Success

**Parameters**

- `[in] handle`: Wifi setting handle
- `[in] data`: Customized data
- `[in] data_len`: Customized data length

esp_err_t **blufi_send_customized_data** (*esp_wifi_setting_handle_t handle*)
Send customized data that be set before.

**Return**

- ESP_FAIL, Fail
- ESP_OK, Success

**Parameters**

- `[in] handle`: Wifi setting handle

### Header File

- wifi_service/include/airkiss_config.h

### Functions

*esp_wifi_setting_handle_t* **airkiss_config_create** (*airkiss_config_info_t *info*)
brief Create airkiss setting handle instance

**Return**

- NULL, Fail
- Others, Success

**Parameters**

- `info`: Configuration of the airkiss

### Structures

**struct airkiss_lan_pack_param_t**
airkiss lan data pack

#### Public Members

void *`appid`
APP identifer data

void *`deviceid`
Device identifer data

`struct airkiss_config_info_t`
airkiss configurations

#### Public Members

*airkiss_lan_pack_param_t* `lan_pack`
User lan pack parameter

bool `ssdp_notify_enable`
Notify enable flag

char *`aes_key`
Airkiss aes key data

### Macros

`AIRKISS_CONFIG_INFO_DEFAULT`()

### Header File

- wifi_service/include/wifi_ssid_manager.h

### Functions

*wifi_ssid_manager_handle_t* `wifi_ssid_manager_create`(uint8_t *max_ssid_num*)

esp_err_t `wifi_ssid_manager_get_latest_config`(*wifi_ssid_manager_handle_t handle*, wifi_config_t **config*)

esp_err_t `wifi_ssid_manager_save`(*wifi_ssid_manager_handle_t handle*, `const` char **ssid*, `const` char **pwd*)

esp_err_t `wifi_ssid_manager_get_best_config`(*wifi_ssid_manager_handle_t handle*, wifi_config_t **config*)

int `wifi_ssid_manager_get_ssid_num`(*wifi_ssid_manager_handle_t handle*)

esp_err_t `wifi_ssid_manager_list_show`(*wifi_ssid_manager_handle_t handle*)

esp_err_t `wifi_ssid_manager_erase_all`(*wifi_ssid_manager_handle_t handle*)

esp_err_t `wifi_ssid_manager_destroy`(*wifi_ssid_manager_handle_t handle*)

### Type Definitions

**typedef struct** wifi_ssid_manager ***wifi_ssid_manager_handle_t**

## 2.6.4 OTA Service

[]

OTA service can upgrade firmware over the air (OTA). The firmware can be fetched from local files or the network.

### Application Example

Implementation of this API is demonstrated in the following example:

- ota

### Header File

- ota_service/include/ota_service.h

### Functions

*periph_service_handle_t* **ota_service_create** (*ota_service_config_t *config*)

Create the OTA service instance.

**Return**

- NULL: Failed
- Others: Success

**Parameters**

- `config`: configuration of the OTA service

esp_err_t **ota_service_set_upgrade_param** (*periph_service_handle_t handle*, *ota_upgrade_ops_t *list*, int *list_len*)

Configure the upgrade parameter This function is not thread safe.

This function will set the parameter table to ota service, and the ota service will upgrade the partitions defined in the table one by one,

**Return**

- ESP_OK: Success
- Others: Failed

**Parameters**

- `[in] handle`: pointer to 'periph_service_handle_t' structure
- `[in] list`: pointer to '*ota_upgrade_ops_t*' structure
- `[in] list_len`: length of the 'list'

### Structures

**struct ota_service_config_t**
The OTA service configuration.

#### Public Members

int **task_stack**
>0 Service task stack; =0 with out task created

int **task_prio**
Service task priority (based on freeRTOS priority)

int **task_core**
Service task running in core (0 or 1)

*periph_service_cb* **evt_cb**
Service callback function

void ***cb_ctx**
Callback context

**struct ota_node_attr_t**
The OTA node attributions.

#### Public Members

esp_partition_type_t **type**
Partition type

char ***label**
Partition label

char ***uri**
The upgrade URL

char ***cert_pem**
SSL server certification, PEM format as string, if the client requires to verify server

**struct ota_upgrade_ops_t**
The upgrade operation.

#### Public Members

*ota_node_attr_t* **node**
The OTA node

*ota_service_err_reason_t* (***prepare**) (void **handle, *ota_node_attr_t* *node)
Functions ready for upgrade

*ota_service_err_reason_t* (***need_upgrade**) (void *handle, *ota_node_attr_t* *node)
Detect whether an upgrade is required

*ota_service_err_reason_t* (***execute_upgrade**) (void *handle, *ota_node_attr_t* *node)
For execute upgrade

*ota_service_err_reason_t* (***finished_check**) (void *handle, *ota_node_attr_t* *node, *ota_service_err_reason_t* result)

Check result of upgrade

bool **reboot_flag**

Reboot or not after upgrade

bool **break_after_fail**

Abort upgrade when got failed

**struct ota_result_t**

The result of the OTA upgrade.

#### Public Members

uint8_t **id**

The result ID

*ota_service_err_reason_t* **result**

The error reason

### Macros

**OTA_SERVICE_ERR_REASON_BASE**

**OTA_SERVICE_DEFAULT_CONFIG**()

### Enumerations

**enum ota_service_event_type_t**

The OTA service event type.

*Values:*

**OTA_SERV_EVENT_TYPE_RESULT**

**OTA_SERV_EVENT_TYPE_FINISH**

**enum ota_service_err_reason_t**

The OTA service error reasons.

*Values:*

**OTA_SERV_ERR_REASON_UNKNOWN** = ESP_FAIL

**OTA_SERV_ERR_REASON_SUCCESS** = ESP_OK

**OTA_SERV_ERR_REASON_NULL_POINTER** = OTA_SERVICE_ERR_REASON_BASE + 1

**OTA_SERV_ERR_REASON_URL_PARSE_FAIL** = OTA_SERVICE_ERR_REASON_BASE + 2

**OTA_SERV_ERR_REASON_ERROR_VERSION** = OTA_SERVICE_ERR_REASON_BASE + 3

**OTA_SERV_ERR_REASON_NO_HIGHER_VERSION** = OTA_SERVICE_ERR_REASON_BASE + 4

**OTA_SERV_ERR_REASON_ERROR_MAGIC_WORD** = OTA_SERVICE_ERR_REASON_BASE + 5

**OTA_SERV_ERR_REASON_ERROR_PROJECT_NAME** = OTA_SERVICE_ERR_REASON_BASE + 6

**OTA_SERV_ERR_REASON_FILE_NOT_FOUND** = OTA_SERVICE_ERR_REASON_BASE + 7

**OTA_SERV_ERR_REASON_PARTITION_NOT_FOUND** = OTA_SERVICE_ERR_REASON_BASE + 8

**OTA_SERV_ERR_REASON_PARTITION_WT_FAIL** = OTA_SERVICE_ERR_REASON_BASE + 9

**OTA_SERV_ERR_REASON_PARTITION_RD_FAIL** = OTA_SERVICE_ERR_REASON_BASE + 10

**OTA_SERV_ERR_REASON_STREAM_INIT_FAIL** = OTA_SERVICE_ERR_REASON_BASE + 11

**OTA_SERV_ERR_REASON_STREAM_RD_FAIL** = OTA_SERVICE_ERR_REASON_BASE + 12

**OTA_SERV_ERR_REASON_GET_NEW_APP_DESC_FAIL** = OTA_SERVICE_ERR_REASON_BASE + 13

### Header File

- ota_service/include/ota_proc_default.h

### Functions

void **ota_app_get_default_proc**(*ota_upgrade_ops_t* **ops*)
get the default process of `app partition` upgrade

**Return**

- void

**Parameters**

- `[in] ops`: pointer to *ota_upgrade_ops_t* structure

void **ota_data_get_default_proc**(*ota_upgrade_ops_t* **ops*)
get the default process of `data partition` upgrade

**Return**

- void

**Parameters**

- `[in] ops`: pointer to *ota_upgrade_ops_t* structure

*ota_service_err_reason_t* **ota_data_image_stream_read**(void **handle*, char **buf*, int *wanted_size*)
read from the stream of upgrading

**Return**

- OTA_SERV_ERR_REASON_SUCCESS: Success
- Others: Failed

**Parameters**

- `[in] handle`: pointer to upgrade handle
- `[in] buf`: pointer to receive buffer
- `[in] wanted_size`: bytes to read

*ota_service_err_reason_t* **ota_data_partition_write**(void **handle*, char **buf*, int *size*)
write to the data partition under upgrading

**Return**

- OTA_SERV_ERR_REASON_SUCCESS: Success
- Others: Failed

**Parameters**

- `[in] handle`: pointer to upgrade handle
- `[in] buf`: pointer to data buffer
- `[in] size`: bytes to write

void **`ota_data_partition_erase_mark`**(void **handle*)
Indicates that the ota partition has been erased By default, this part of flash will be erased during ota. If the behavior of erasing is called in applition, this API needs to be called.

**Return**

- void

**Parameters**

- `[in] handle`: pointer to upgrade handle

int **`ota_get_version_number`**(char **version*)
Convert string of version to integer The version should be (V0.0.0 - V255.255.255)

**Return**

- -1: Failed
- Others: version number

**Parameters**

- `[in] version`: pointer to the string of version

### Header File

- ota_service/include/esp_fs_ota.h

### Functions

esp_err_t **`esp_fs_ota`**(*esp_fs_ota_config_t* **ota_config*)
Upgrade the firmware from filesystem.

**Note** This API handles the entire OTA operation, so if this API is being used then no other APIs from `esp_fs_ota` component should be called. If more information and control is needed during the FS OTA process, then one can use `esp_fs_ota_begin` and subsequent APIs. If this API returns successfully, esp_restart() must be called to boot from the new firmware image.

**Return**

- ESP_OK: OTA data updated, next reboot will use specified partition.
- ESP_FAIL: For generic failure.
- ESP_ERR_INVALID_ARG: Invalid argument

- ESP_ERR_OTA_VALIDATE_FAILED: Invalid app image
- ESP_ERR_NO_MEM: Cannot allocate memory for OTA operation.
- ESP_ERR_FLASH_OP_TIMEOUT or ESP_ERR_FLASH_OP_FAIL: Flash write failed.
- For other return codes, refer OTA documentation in esp-idf's app_update component.

**Parameters**

- `[in] ota_config`: pointer to *esp_fs_ota_config_t* structure.

esp_err_t **esp_fs_ota_begin**(*esp_fs_ota_config_t* **ota_config*, *esp_fs_ota_handle_t* **handle*)

Start FS OTA Firmware upgrade.

This function initializes ESP FS OTA context and open the firmware file. This function must be invoked first. If this function returns successfully, then `esp_fs_ota_perform` should be called to continue with the OTA process and there should be a call to `esp_fs_ota_finish` on completion of OTA operation or on failure in subsequent operations.

**Return**

- ESP_OK: FS OTA Firmware upgrade context initialised and file opened successful
- ESP_FAIL: For generic failure.
- ESP_ERR_INVALID_ARG: Invalid argument (missing/incorrect config, etc.)
- For other return codes, refer documentation in app_update component and esp_http_client component in esp-idf.

**Parameters**

- `[in] ota_config`: pointer to *esp_fs_ota_config_t* structure
- `[out] handle`: pointer to an allocated data of type `esp_fs_ota_handle_t` which will be initialised in this function

esp_err_t **esp_fs_ota_perform**(*esp_fs_ota_handle_t* *fs_ota_handle*)

Read image data from file stream and write it to OTA partition.

This function reads image data from file stream and writes it to OTA partition. This function must be called only if esp_fs_ota_begin() returns successfully. This function must be called in a loop since it returns after every file read operation thus giving you the flexibility to stop OTA operation midway.

**Return**

- ESP_ERR_FS_OTA_IN_PROGRESS: OTA update is in progress, call this API again to continue.
- ESP_OK: OTA update was successful
- ESP_FAIL: OTA update failed
- ESP_ERR_INVALID_ARG: Invalid argument
- ESP_ERR_OTA_VALIDATE_FAILED: Invalid app image
- ESP_ERR_NO_MEM: Cannot allocate memory for OTA operation.
- ESP_ERR_FLASH_OP_TIMEOUT or ESP_ERR_FLASH_OP_FAIL: Flash write failed.
- For other return codes, refer OTA documentation in esp-idf's app_update component.

**Parameters**

- `[in] fs_ota_handle`: pointer to esp_fs_ota_handle_t structure

esp_err_t **esp_fs_ota_finish**(*esp_fs_ota_handle_t fs_ota_handle*)
Clean-up FS OTA Firmware upgrade and close the file stream.

This function closes the file stream and frees the ESP FS OTA context. This function switches the boot partition to the OTA partition containing the new firmware image.

**Note** If this API returns successfully, esp_restart() must be called to boot from the new firmware image

**Return**

- ESP_OK: Clean-up successful
- ESP_ERR_INVALID_STATE
- ESP_ERR_INVALID_ARG: Invalid argument
- ESP_ERR_OTA_VALIDATE_FAILED: Invalid app image

**Parameters**

- `[in] fs_ota_handle`: pointer to esp_fs_ota_handle_t structure

esp_err_t **esp_fs_ota_get_img_desc**(*esp_fs_ota_handle_t fs_ota_handle*, esp_app_desc_t **new_app_info*)
Reads app description from image header. The app description provides information like the "Firmware version" of the image.

**Note** This API can be called only after esp_fs_ota_begin() and before esp_fs_ota_perform(). Calling this API is not mandatory.

**Return**

- ESP_ERR_INVALID_ARG: Invalid arguments
- ESP_FAIL: Failed to read image descriptor
- ESP_OK: Successfully read image descriptor

**Parameters**

- `[in] fs_ota_handle`: pointer to esp_fs_ota_handle_t structure
- `[out] new_app_info`: pointer to an allocated esp_app_desc_t structure

int **esp_fs_ota_get_image_len_read**(*esp_fs_ota_handle_t fs_ota_handle*)

### Structures

**struct esp_fs_ota_config_t**
ESP FS OTA configuration.

#### Public Members

**const** char ***path**
  file path

**const** int **buffer_size**
  Size of buffer

### Macros

**ESP_ERR_FS_OTA_BASE**

**ESP_ERR_FS_OTA_IN_PROGRESS**

### Type Definitions

**typedef** void ***esp_fs_ota_handle_t**

## 2.6.5 DuerOS Service

[]

The DuerOS service allows voice interaction with DuerOS.

### Application Example

Implementation of this API is demonstrated in the following example:

- dueros

### Header File

- dueros_service/include/dueros_service.h

### Functions

*audio_service_handle_t* **dueros_service_create**()
  Create the dueros service.

  **Return**

  - NULL, Fail
  - Others, Success

*service_state_t* **dueros_service_state_get**()
  Get dueros service state.

  **Return** The state of service

esp_err_t **dueros_voice_upload** (*audio_service_handle_t handle*, void **buf*, int *len*)
Upload voice to backend server.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: dueros service handle
- `buf`: Data buffer
- `len`: Size of buffer

esp_err_t **dueros_voice_cancel** (*audio_service_handle_t handle*)
Cancel the current session.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: dueros service handle

esp_err_t **dueros_start_wifi_cfg** (*audio_service_handle_t handle*, duer_wifi_cfg_t **cfg*)
Start the wifi configure process.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Dueros service handle
- `cfg`: Configuration

esp_err_t **dueros_stop_wifi_cfg** (*audio_service_handle_t handle*)
Stop the wifi configure process.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Dueros service handle

esp_err_t **dueros_wifi_status_report** (*audio_service_handle_t handle*, *dueros_wifi_st_t* **st*)
Report the wifi status to dipb.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Dueros service handle
- `st`: WiFi status and error code

### Structures

**struct dueros_wifi_st_t**
Status of WiFi connection.

#### Public Members

int **status**
Please refer to: `enum duer_dipb_client_status_e`

int **err**
Please refer to: `enum duer_wifi_connect_error_code_e`

## 2.6.6 Display Service

[]

The display service defines enumeration values for some common display patterns in *display_pattern_t*, with which you can set the corresponding patterns of LEDs or LED bars.

The currently supported LED drivers are AW2013, WS2812, and IS31x.

### Application Example

Implementation of this API is demonstrated in the following example:

- checks/check_display_led

### Header File

- display_service/include/display_service.h

### Functions

*display_service_handle_t* **display_service_create**(*display_service_config_t* *cfg)

esp_err_t **display_service_set_pattern**(void **handle*, int *disp_pattern*, int *value*)

esp_err_t **display_destroy**(*display_service_handle_t* *handle*)

### Structures

**struct display_service_config_t**
Display service configurations.

### Public Members

*periph_service_config_t* **based_cfg**
Peripheral service configuration

void ***instance**
Sub-instance

### Type Definitions

**typedef struct** display_service_impl ***display_service_handle_t**

### Enumerations

**enum display_pattern_t**
*Values:*

**DISPLAY_PATTERN_UNKNOWN** = 0

**DISPLAY_PATTERN_WIFI_SETTING** = 1

**DISPLAY_PATTERN_WIFI_CONNECTTING** = 2

**DISPLAY_PATTERN_WIFI_CONNECTED** = 3

**DISPLAY_PATTERN_WIFI_DISCONNECTED** = 4

**DISPLAY_PATTERN_WIFI_SETTING_FINISHED** = 5

**DISPLAY_PATTERN_BT_CONNECTTING** = 6

**DISPLAY_PATTERN_BT_CONNECTED** = 7

**DISPLAY_PATTERN_BT_DISCONNECTED** = 8

**DISPLAY_PATTERN_RECORDING_START** = 9

**DISPLAY_PATTERN_RECORDING_STOP** = 10

**DISPLAY_PATTERN_RECOGNITION_START** = 11

**DISPLAY_PATTERN_RECOGNITION_STOP** = 12

**DISPLAY_PATTERN_WAKEUP_ON** = 13

**DISPLAY_PATTERN_WAKEUP_FINISHED** = 14

**DISPLAY_PATTERN_MUSIC_ON** = 15

**DISPLAY_PATTERN_MUSIC_FINISHED** = 16

**DISPLAY_PATTERN_VOLUME** = 17

**DISPLAY_PATTERN_MUTE_ON** = 18

**DISPLAY_PATTERN_MUTE_OFF** = 19

**DISPLAY_PATTERN_TURN_ON** = 20

**DISPLAY_PATTERN_TURN_OFF** = 21

**DISPLAY_PATTERN_BATTERY_LOW** = 22

**DISPLAY_PATTERN_BATTERY_CHARGING** = 23

**DISPLAY_PATTERN_BATTERY_FULL** = 24

**DISPLAY_PATTERN_POWERON_INIT** = 25

**DISPLAY_PATTERN_WIFI_NO_CFG** = 26

**DISPLAY_PATTERN_SPEECH_BEGIN** = 27

**DISPLAY_PATTERN_SPEECH_OVER** = 28

**DISPLAY_PATTERN_MAX**

### Header File

- display_service/led_bar/include/led_bar_aw2013.h

### Functions

void **aw2013_led_bar_task** (void **parameters*)

*esp_periph_handle_t* **led_bar_aw2013_init** (void)

Initialize led bar instance.

**Return**

- NULL Error
- others Success

esp_err_t **led_bar_aw2013_pattern** (void **handle*, int *pat*, int *value*)

Set led bar display pattern.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: led bar instance
- `pat`: display pattern
- `value`: value of pattern

esp_err_t **led_bar_aw2013_set_blink_time** (void **handle*, uint8_t *time*, int *period*)

Set blinking period and times.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: led bar instance
- `time`: times of blink
- `period`: period of blink

void **led_bar_aw2013_deinit** (*esp_periph_handle_t handle*)
Destroy esp_periph_handle_t instance.

**Parameters**

- `handle`: led bar instance

### Header File

- display_service/led_bar/include/led_bar_is31x.h

### Functions

*esp_periph_handle_t* **led_bar_is31x_init** ()
Initialize esp_periph_handle_t instance.

**Return**

- NULL, Fail
- Others, Success

esp_err_t **led_bar_is31x_pattern** (void **handle*, int *pat*, int *value*)
Set led bar display pattern.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: led bar instance
- `pat`: display pattern
- `value`: value of pattern

void **led_bar_is31x_deinit** (*esp_periph_handle_t handle*)
Destroy esp_periph_handle_t instance.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: led bar instance

### Header File

- display_service/led_bar/include/led_bar_ws2812.h

### Functions

*led_bar_ws2812_handle_t* **led_bar_ws2812_init** (gpio_num_t *gpio_num*, int *led_num*)

Initialize led_bar_ws2812_handle_t instance.

**Return**

- led_bar_ws2812_handle_t

**Parameters**

- `gpio_num`: The GPIO number of ws2812
- `led_num`: The number of all ws2812

esp_err_t **led_bar_ws2812_pattern** (void **handle*, int *pat*, int *value*)

Set ws2812 pattern.

**Return**

- ESP_OK, success
- Others, fail

**Parameters**

- `handle`: ws2812 indicator instance
- `pat`: display pattern
- `value`: value of pattern

esp_err_t **led_bar_ws2812_deinit** (*led_bar_ws2812_handle_t handle*)

Destroy led_bar_ws2812_handle_t instance.

**Return**

**Return**

- ESP_OK, success
- Others, fail

**Parameters**

- `handle`: ws2812 indicator instance

### Type Definitions

**typedef struct** led_bar_ws2812_impl ***led_bar_ws2812_handle_t**

### Header File

- display_service/led_indicator/include/led_indicator.h

### Functions

*led_indicator_handle_t* **led_indicator_init** (gpio_num_t *num*)

Initialize led_indicator_handle_t instance.

**Return**

- NULL, Fail
- Others, Success

**Parameters**

- `num`: led gpio number

esp_err_t **led_indicator_pattern** (void **handle*, int *pat*, int *value*)

Set led indicator display pattern.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: led indicator instance
- `pat`: display pattern
- `value`: value of pattern

void **led_indicator_deinit** (*led_indicator_handle_t* *handle*)

Destroy led_indicator_handle_t instance.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `handle`: led indicator instance

#### Type Definitions

**typedef struct** led_indicator_impl ***led_indicator_handle_t**

### 2.6.7 Battery Service

[]

The battery service can monitor and manage battery voltage. You can access battery voltage and the events defined by `battery_service_event_t` through callback functions.

#### Application Example

Implementation of this API is demonstrated in the following example:

- system/battery

#### Header File

- battery_service/include/battery_service.h

#### Functions

*periph_service_handle_t* **battery_service_create**(*battery_service_config_t *config*)
Create the battery service instance.

**Return**

- NULL: Failed
- Others: Success

**Parameters**

- `config`: configuration of the battery service

esp_err_t **battery_service_vol_report_switch**(*periph_service_handle_t handle*, bool *on_off*)
Start or stop the battery voltage report.

**Return**

- ESP_OK: Success
- ESP_ERR_INVALID_ARG handle is NULL

**Parameters**

- `[in] handle`: pointer to 'periph_service_handle_t' structure
- `[in] on_off`: 'true' to start, 'false' to stop

esp_err_t **battery_service_set_vol_report_freq**(*periph_service_handle_t handle*, int *freq*)
Set voltage report freqency.

**Return**

- ESP_OK: Success
- ESP_ERR_INVALID_ARG handle is NULL

**Parameters**

- `[in] handle`: pointer to 'periph_service_handle_t' structure
- `[in] freq`: voltage report freqency

### Structures

**struct battery_service_config_t**

Battery service configure.

#### Public Members

int **task_stack**

>0 Service task stack; =0 with out task created

int **task_prio**

Service task priority (based on freeRTOS priority)

int **task_core**

Service task running in core (0 or 1)

bool **extern_stack**

Task stack allocate on the extern ram

*periph_service_cb* **evt_cb**

Service callback function

void ***cb_ctx**

Callback context

*vol_monitor_handle_t* **vol_monitor**

Battery monitor

void ***charger_monitor**

Charger monitor. Not supported yet

### Macros

**BATTERY_SERVICE_DEFAULT_CONFIG()**

### Enumerations

**enum battery_service_event_t**

Battery service event.

*Values:*

**BAT_SERV_EVENT_UNKNOWN**

**BAT_SERV_EVENT_VOL_REPORT** = 1

**BAT_SERV_EVENT_BAT_FULL**

**BAT_SERV_EVENT_BAT_LOW**

**BAT_SERV_EVENT_CHARGING_BEGIN** = 100

**BAT_SERV_EVENT_CHARGING_STOP**

### Header File

- battery_service/monitors/include/voltage_monitor.h

### Functions

*vol_monitor_handle_t* **vol_monitor_create** (*vol_monitor_param_t *config*)

Create the voltage monitor instance.

**Return**

- NULL: Failed
- Others: Success

**Parameters**

- `[in] config`: pointer to '*vol_monitor_param_t*' structure

esp_err_t **vol_monitor_destroy** (*vol_monitor_handle_t handle*)

Destroy the voltage monitor.

**Return**

- ESP_OK: Success
- Others: Failed

**Parameters**

- `[in] handle`: pointer to 'vol_monitor_handle_t' structure

esp_err_t **vol_monitor_set_event_cb** (*vol_monitor_handle_t handle*, *vol_monitor_event_cb event_cb*, void **user_ctx*)

Set the event callback.

**Return**

- ESP_OK: Success
- Others: Failed

**Parameters**

- `[in] handle`: pointer to 'vol_monitor_handle_t' structure
- `[in] event_cb`: callback used to handle the events of voltage monitor
- `[in] user_ctx`: user's data

esp_err_t **vol_monitor_start_freq_report** (*vol_monitor_handle_t handle*)

Start the voltage report with the configured frequency.

**Return**

- ESP_OK: Success
- Others: Failed

**Parameters**

- `[in] handle`: pointer to 'vol_monitor_handle_t' structure

esp_err_t **vol_monitor_stop_freq_report** (*vol_monitor_handle_t handle*)

Stop the voltage frequency report.

**Return**

- ESP_OK: Success
- Others: Failed

**Parameters**

- `[in] handle`: pointer to 'vol_monitor_handle_t' structure

esp_err_t **vol_monitor_set_report_freq** (*vol_monitor_handle_t handle*, int *freq*)

Set the voltage report frequency.

**Return**

- ESP_OK: Success
- Others: Failed

**Parameters**

- `[in] handle`: pointer to 'vol_monitor_handle_t' structure
- `[in] freq`: voltage report freqency

### Structures

**struct vol_monitor_param_t**

Battery adc configure.

#### Public Members

bool (***init**) (void *)

Voltage read init

bool (***deinit**) (void *)

Voltage read deinit

int (***vol_get**) (void *)

Voltage read interface

void ***user_data**

Parameters for callbacks

int **read_freq**

Voltage read frequency, unit: s

int **report_freq**

Voltage report frequency, voltage will be report with a interval calculate by `read_freq * report_freq`

int **vol_full_threshold**
Voltage threshold to report, unit: mV

int **vol_low_threshold**
Voltage threshold to report, unit: mV

### Type Definitions

**typedef** void ***vol_monitor_handle_t**
voltage monitor handle

**typedef** void (***vol_monitor_event_cb**) (int msg_id, void *data, void *user_ctx)
callback define

### Enumerations

**enum vol_monitor_event_t**
Battery adc configure.

*Values:*

**VOL_MONITOR_EVENT_FREQ_REPORT**

**VOL_MONITOR_EVENT_BAT_FULL**

**VOL_MONITOR_EVENT_BAT_LOW**

## 2.6.8 Core Dump Upload Service

[]

To investigate crashes in some sold devices, the backtrace is needed for analysis. The core dump upload service transmits the backtrace stored in the device partition over HTTP. To enable this feature, select `ESP_COREDUMP_ENABLE_TO_FLASH`.

### Application Example

Implementation of this API is demonstrated in the following example:

- system/coredump

### Header File

- coredump_upload_service/include/coredump_upload_service.h

### Functions

bool **`coredump_need_upload`**()

This function will check the reset code and determine whether to upload the coredump.

**Return**

- true: last reboot is a abnormal reset.
- false

esp_err_t **`coredump_upload`**(*periph_service_handle_t handle*, char **url*)

Upload the core dump image to the url. This function will block the current task until the upload process finished.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] handle`: the 'periph_service_handle_t'
- `[in] url`: server addr

*periph_service_handle_t* **`coredump_upload_service_create`**(*coredump_upload_service_config_t *config*)

Create the core dump upload service instance.

**Return**

- NULL: Failed
- Others: Success

**Parameters**

- `config`: configuration of the OTA service

### Structures

**`struct coredump_upload_service_config_t`**

coredump service configuration parameters

#### Public Members

int **`task_stack`**

>0 Service task stack; =0 with out task created

int **`task_prio`**

Service task priority (based on freeRTOS priority)

int **`task_core`**

Service task running in core (0 or 1)

*periph_service_cb* **`evt_cb`**

Service callback function

void ***cb_ctx**
: Callback context

bool (***do_post**)(char *url, uint8_t *data, size_t len)
: POST interface, users can override this to customize the http client. if left NULL, the service will use the default one

### Macros

**COREDUMP_UPLOAD_SERVICE_DEFAULT_CONFIG**()

## 2.6.9 Header File

- esp_dispatcher/include/periph_service.h

## 2.6.10 Functions

*periph_service_handle_t* **periph_service_create**(*periph_service_config_t* **config*)
: brief Create peripheral service instance

**Return**

- NULL, Fail
- Others, Success

**Parameters**

- `[in] config`: Configuration of the peripheral service instance

esp_err_t **periph_service_destroy**(*periph_service_handle_t handle*)
: brief Destroy peripheral service instance

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The peripheral service instance

esp_err_t **periph_service_start**(*periph_service_handle_t handle*)
: brief Start the specific peripheral service

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The peripheral service instance

esp_err_t **periph_service_stop** (*periph_service_handle_t handle*)
brief Stop the specific peripheral service

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The peripheral service instance

esp_err_t **periph_service_set_callback** (*periph_service_handle_t handle*, *periph_service_cb cb*, void **ctx*)
brief Set the specific peripheral service callback function

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The peripheral service instance
- `[in] cb`: A pointer to service_callback
- `[in] ctx`: A pointer to user context

esp_err_t **periph_service_callback** (*periph_service_handle_t handle*, *periph_service_event_t *evt*)
brief Called peripheral service by configurations

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The peripheral service instance
- `[in] evt`: A pointer to *periph_service_event_t*

esp_err_t **periph_service_set_data** (*periph_service_handle_t handle*, void **data*)
brief Set user data to specific peripheral service instance

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The peripheral service instance

- `[in] data`: A pointer to user data

void ***periph_service_get_data** (*periph_service_handle_t handle*)

brief Get user data by specific peripheral service instance

**Return** A pointer to user data

**Parameters**

- `[in] handle`: The peripheral service instance

esp_err_t **periph_service_ioctl** (*periph_service_handle_t handle*, void **ioctl_handle*, int *cmd*, int *value*)

brief In/out control by peripheral service instance

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The peripheral service instance
- `[in] ioctl_handle`: Sub-instance handle
- `[in] cmd`: Command of value
- `[in] value`: Data of the command

## 2.6.11 Structures

**struct periph_service_event_t**

Peripheral service event informations.

### Public Members

int **type**

Type of event

void ***source**

Event source

void ***data**

Event data

int **len**

Length of data

**struct periph_service_config_t**

Peripheral service configurations.

#### Public Members

int **task_stack**
>0 Service task stack; =0 with out task created

int **task_prio**
Service task priority (based on freeRTOS priority)

int **task_core**
Service task running in core (0 or 1)

TaskFunction_t **task_func**
Service task function

bool **extern_stack**
Task stack allocate on the extern ram

*periph_service_ctrl* **service_start**
Start function

*periph_service_ctrl* **service_stop**
Stop function

*periph_service_ctrl* **service_destroy**
Destroy function

*periph_service_io* **service_ioctl**
In out control function

char ***service_name**
Name of peripheral service

void ***user_data**
User data

### 2.6.12 Type Definitions

**typedef struct** periph_service_impl ***periph_service_handle_t**

**typedef** esp_err_t (***periph_service_ctrl**) (*periph_service_handle_t* handle)

**typedef** esp_err_t (***periph_service_io**) (void *ioctl_handle, int cmd, int value)

**typedef** esp_err_t (***periph_service_cb**) (*periph_service_handle_t* handle, *periph_service_event_t* *evt, void *ctx)

### 2.6.13 Enumerations

**enum periph_service_state_t**
Peripheral service state.

*Values:*

**PERIPH_SERVICE_STATE_UNKNOWN**

**PERIPH_SERVICE_STATE_IDLE**

**PERIPH_SERVICE_STATE_RUNNING**

**PERIPH_SERVICE_STATE_STOPPED**

### 2.6.14 Header File

- esp_dispatcher/include/audio_service.h

### 2.6.15 Functions

*audio_service_handle_t* **audio_service_create**(*audio_service_config_t *config*)
brief Create audio service instance

**Return**

- NULL, Fail
- Others, Success

**Parameters**

- `[in] config`: Configuration of the audio service instance

esp_err_t **audio_service_destroy**(*audio_service_handle_t handle*)
brief Destroy audio service instance

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The audio service instance

esp_err_t **audio_service_start**(*audio_service_handle_t handle*)
brief Start the specific audio service

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The audio service instance

esp_err_t **audio_service_stop**(*audio_service_handle_t handle*)
brief Stop the specific audio service

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The audio service instance

esp_err_t **audio_service_set_callback**(*audio_service_handle_t handle*, *service_callback cb*, void **ctx*)

brief Set the specific audio service callback function.

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The audio service instance
- `[in] cb`: A pointer to service_callback
- `[in] ctx`: A pointer to user context

esp_err_t **audio_service_callback**(*audio_service_handle_t handle*, *service_event_t *evt*)

brief Called audio service by configurations

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The audio service instance
- `[in] evt`: A pointer to *service_event_t*

esp_err_t **audio_service_connect**(*audio_service_handle_t handle*)

brief Connect the specific audio service

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The audio service instance

esp_err_t **audio_service_disconnect**(*audio_service_handle_t handle*)

brief Disconnect the specific audio service

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The audio service instance

esp_err_t **audio_service_set_data** (*audio_service_handle_t handle*, void **data*)

brief Set user data to specific audio service instance

**Return**

- ESP_OK
- ESP_FAIL
- ESP_ERR_INVALID_ARG

**Parameters**

- `[in] handle`: The audio service instance
- `[in] data`: A pointer to user data

void ***audio_service_get_data** (*audio_service_handle_t handle*)

brief Get user data by specific audio service instance

**Return** A pointer to user data

**Parameters**

- `[in] handle`: The audio service instance

## 2.6.16 Structures

**struct service_event_t**

Audio service event informations.

### Public Members

int **type**

Type of event

void ***source**

Event source

void ***data**

Event data

int **len**

Length of data

**struct audio_service_config_t**

Audio service configurations.

### Public Members

int **task_stack**
>0 Service task stack; =0 with out task created

int **task_prio**
Service task priority (based on freeRTOS priority)

int **task_core**
Service task running in core (0 or 1)

TaskFunction_t **task_func**
A pointer to TaskFunction_t for service task function

*service_ctrl* **service_start**
Start function

*service_ctrl* **service_stop**
Stop function

*service_ctrl* **service_connect**
Connect function

*service_ctrl* **service_disconnect**
Disconnect function

*service_ctrl* **service_destroy**
Destroy function

**const** char ***service_name**
Name of audio service

void ***user_data**
User context

## 2.6.17 Type Definitions

**typedef struct** audio_service_impl ***audio_service_handle_t**

**typedef** esp_err_t (***service_ctrl**)(*audio_service_handle_t* handle)

**typedef** esp_err_t (***service_callback**)(*audio_service_handle_t* handle, *service_event_t* *evt, void *ctx)

## 2.6.18 Enumerations

**enum service_state_t**
Audio service state.

*Values:*

**SERVICE_STATE_UNKNOWN**

**SERVICE_STATE_IDLE**

**SERVICE_STATE_CONNECTING**

**SERVICE_STATE_CONNECTED**

**SERVICE_STATE_RUNNING**

**SERVICE_STATE_STOPPED**

## 2.7 Speech Recognition

ESP-ADF offers a comprehensive range of speech recognition processing functions, such as front-end speech processing, TTS, voice wake-up, and command word recognition. ESP-ADF's Element-based *audio recorder* integrates speech recognition and audio signal processing into an event-driven High-level API. This approach enables users to maintain flexibility in their configurations while making it easier to use.

### 2.7.1 Voice Activity Detection

Voice activity detection (VAD) is a technique used in speech processing to detect the presence (or absence) of human speech. Detection of somebody speaking may be used to activate some processes, e.g. automatically switch on voice recording. It may be also used to deactivate processes, e.g. stop coding and transmission of silence packets to save on computation and network bandwidth.

Provided in this section API implements VAD functionality together with couple of options to configure sensitivity of speech detection, set sample rate or duration of audio samples.

#### Application Example

Implementation of the voice activity detection API is demonstrated in speech_recognition/vad example.

#### API Reference

For the latest API reference please refer to Espressif Speech recognition repository.

### 2.7.2 WakeNet Interface

Setting up the speech recognition application to detect a wakeup word may be done using series of Audio Elements linked into a pipeline shown below.

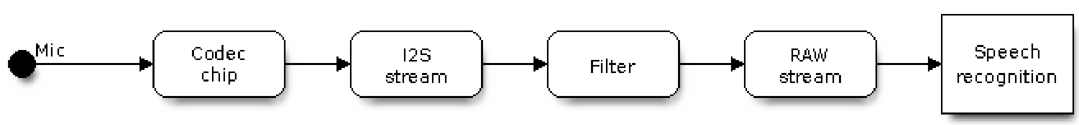


Fig. 5: Sample Speech Recognition Pipeline

Configuration and use of particular elements is demonstrated in several examples linked to elsewhere in this documentation. What may need clarification is use of the **Filter** and the **RAW stream**. The filter is used to adjust the sample rate of the I2S stream to match the sample rate of the speech recognition model. The RAW stream is the way to feed the audio input to the model.

The above introduction is the primary guidance. ESP-ADF offers users a more flexible and convenient module, namely the *audio recorder*, which is strongly recommended for use.

#### API Reference

For the latest speech recognition API reference, please refer to ESP-SR Speech Recognition Framework.

### 2.7.3 Audio Recorder

The Audio Recorder API is a set of functions to facilitate voice recording. It combines two important functions, namely Audio Front End (AFE) and audio encoding. This allows users to customize AFE's Voice Activity Detection (VAD), Automatic Gain Control (AGC), and Acoustic Echo Cancellation (AEC) settings. The encoding function is used by users to establish the encoding audio element, which supports various formats such as AAC, AMR-NB, AMR-WB, ADPCM, WAV, OPUS, and G711. The *audio_rec_evt_t* event makes it easy for users to interact with the Audio Recorder software.

The data path of the Audio recorder is presented in the diagram below.

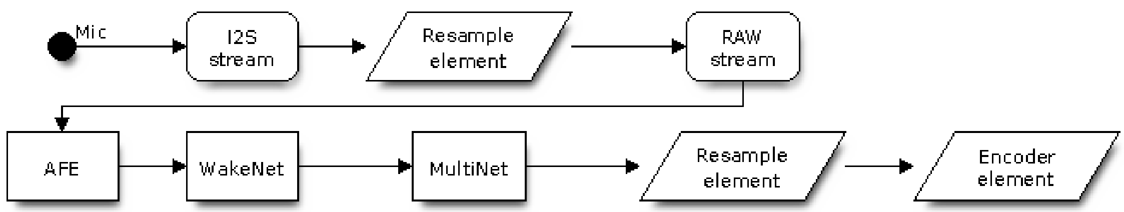


Fig. 6: Audio recorder data path

The area represented by the parallelogram is configurable by the user according to their needs, such as sampling frequency, whether to encode, and encoding format.

#### Application Example

The speech_recognition/wwe/ example demonstrates how to initialize the speech recognition model, determine the number of samples and the sample rate of voice data to feed to the model, detect the wake-up word and command words, and encode voice to specific audio format.

#### API Reference

#### Header File

- audio_recorder/include/audio_recorder.h

### Functions

*audio_rec_handle_t* **audio_recorder_create**(*audio_rec_cfg_t *cfg*)
Initialize and start up audio recorder.

**Return** NULL failed Others audio recorder handle

**Parameters**

- `cfg`: Configuration of audio recorder

esp_err_t **audio_recorder_trigger_start**(*audio_rec_handle_t handle*)
Start recording by force.

**Note** If there need to read from recorder without wake word detected or read from recorder while the wake word detection is disabled, this interface can be use to force start the recorder process.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Audio recorder handle

esp_err_t **audio_recorder_trigger_stop**(*audio_rec_handle_t handle*)
Stop recording by force.

**Note** No matter the recorder process is triggered by wake word detected or triggered by `audio_recorder_trigger_start`, this function can be used to force stop the recorder. And if the VAD detection is disabeled, this must be invoked to stop recording after `audio_recorder_trigger_start`.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Audio recorder handle

esp_err_t **audio_recorder_wakenet_enable**(*audio_rec_handle_t handle*, bool *enable*)
Enable or suspend wake word detection.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Audio recorder handle
- `enable`: true: enable wake word detection false: disable wake word detection

esp_err_t **audio_recorder_multinet_enable**(*audio_rec_handle_t handle*, bool *enable*)
Enable or suspend speech command recognition.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Audio recorder handle
- `enable`: true: enable speech command recognition false: disable speech command recognition

esp_err_t **audio_recorder_vad_check_enable**(*audio_rec_handle_t handle*, bool *enable*)
Enable or suspend voice duration check.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Audio recorder handle
- `enable`: true: enable voice duration check false: disable voice duration check

int **audio_recorder_data_read**(*audio_rec_handle_t handle*, void **buffer*, int *length*, TickType_t *ticks*)
Read data from audio recorder.

**Return** Length of data actually read ESP_ERR_INVALID_ARG

**Parameters**

- `handle`: Audio recorder handle
- `buffer`: Buffer to save data
- `length`: Size of buffer
- `ticks`: Timeout for reading

esp_err_t **audio_recorder_destroy**(*audio_rec_handle_t handle*)
Destroy audio recorder and recycle all resource.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Audio recorder handle

bool **audio_recorder_get_wakeup_state**(*audio_rec_handle_t handle*)
Get the wake up state of audio recorder.

**Return** true false

**Parameters**

- `handle`: Audio recorder handle

### Structures

**struct audio_rec_evt_t**
Recorder event.

#### Public Types

**enum [anonymous]**
Audio recorder event type.

*Values:*

**AUDIO_REC_WAKEUP_START** = -100
Wakeup start

**AUDIO_REC_WAKEUP_END**
Wakeup stop

**AUDIO_REC_VAD_START**
Vad start

**AUDIO_REC_VAD_END**
Vad stop

**AUDIO_REC_COMMAND_DECT** = 0
Form 0 is the id of the voice commands detected by Multinet

### Public Members

*audio_rec_evt_t*::**[anonymous] type**
Audio recorder event type.

Event type

void ***event_data**
Event data: For `AUDIO_REC_WAKEUP_START`, event data is `recorder_sr_wakeup_result_t` For `AUDIO_REC_COMMAND_DECT` or higher, event data is `recorder_sr_mn_result_t` For other events, event data is NULL

size_t **data_len**
Length of event data

**struct audio_rec_cfg_t**
Audio recorder configuration.

### Public Members

int **pinned_core**
Audio recorder task pinned to core

int **task_prio**
Audio recorder task priority

int **task_size**
Audio recorder task stack size

*rec_event_cb_t* **event_cb**
Event callback function, event type as *audio_rec_evt_t* shown above

void ***user_data**
Pointer to user data (optional)

recorder_data_read_t **read**
Data callback function used feed data to audio recorder

void ***sr_handle**
SR handle

recorder_sr_iface_t ***sr_iface**
SR interface

int **wakeup_time**
Unit:ms. The duration that the wakeup state remains when VAD is not triggered

int **vad_start**
Unit:ms. Consecutive speech frame will be judged to vad start

int **vad_off**
Unit:ms. When the silence time exceeds this value, it is determined as AUDIO_REC_VAD_END state

int **wakeup_end**
Unit:ms. When the silence time after AUDIO_REC_VAD_END state exceeds this value, it is determined as AUDIO_REC_WAKEUP_END

void ***encoder_handle**
Encoder handle

recorder_encoder_iface_t ***encoder_iface**
Encoder interface

### Macros

**AUDIO_REC_DEF_TASK_SZ**
Stack size of recorder task

**AUDIO_REC_DEF_TASK_PRIO**
Priority of recoder task

**AUDIO_REC_DEF_TASK_CORE**
Pinned to core

**AUDIO_REC_DEF_WAKEUP_TM**
Default wake up time (ms)

**AUDIO_REC_DEF_WAKEEND_TM**
Duration after vad off (ms)

**AUDIO_REC_VAD_START_SPEECH_MS**
Consecutive speech frame will be judged to vad start (ms)

**AUDIO_REC_DEF_VAD_OFF_TM**
Default vad off time (ms)

**AUDIO_RECORDER_DEFAULT_CFG**()

### Type Definitions

**typedef** esp_err_t (***rec_event_cb_t**) (*audio_rec_evt_t* *event, void *user_data)
Event Notification.

**typedef struct** __audio_recorder ***audio_rec_handle_t**
Audio recorder handle.

### Header File

- audio_recorder/include/recorder_sr.h

### Functions

*recorder_sr_handle_t* **recorder_sr_create**(*recorder_sr_cfg_t* **cfg*, recorder_sr_iface_t ***iface*)

Initialize sr processor, and the sr is disabled as default.

**Return** NULL failed Others SR handle

**Parameters**

- `cfg`: Configuration of sr
- `iface`: User interface provide by recorder sr

esp_err_t **recorder_sr_destroy**(*recorder_sr_handle_t handle*)

Destroy SR processor and recycle all resource.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: SR processor handle

esp_err_t **recorder_sr_reset_speech_cmd**(*recorder_sr_handle_t handle*, char **command_str*, char **err_phrase_id*)

Reset the speech commands.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: SR processor handle
- `command_str`: String of the commands. more details on `#2reset-api-on-the-fly`
- `err_phrase_id`: error string output

### Structures

**struct recorder_sr_cfg_t**

SR processor configuration.

**Note** Since the detection of command words requires a clear starting point, the moment the wake word is detected is taken as the default start of detection. Therefore, if the wake word detection is disabled, the detection will use the `vad_state` detected by `esp-sr` as the start of detection. However, due to the fluctuation of this `vad_state`, the effectiveness of command word detection will be limited.

#### Public Members

afe_config_t **afe_cfg**

Configuration of AFE

int8_t **input_order**[**DAT_CH_MAX**]

Channel order of the input data

bool **multinet_init**

Enable of speech command recognition

int **feed_task_core**
Core id of feed task

int **feed_task_prio**
Priority of feed task

int **feed_task_stack**
Stack size of feed task

int **fetch_task_core**
Core id of fetch task

int **fetch_task_prio**
Priority of fetch task

int **fetch_task_stack**
Stack size of fetch task

int **rb_size**
Ringbuffer size of recorder sr

char ***partition_label**
Partition label which stored the model data

char ***mn_language**
Command language for multinet to load

char ***wn_wakeword**
Wake Word for WakeNet to load. This is useful when multiple Wake Words are selected in sdkconfig. Setting this to NULL will use the first found model.

### Macros

**FEED_TASK_STACK_SZ**

**FETCH_TASK_STACK_SZ**

**FEED_TASK_PRIO**

**FETCH_TASK_PRIO**

**FEED_TASK_PINNED_CORE**

**FETCH_TASK_PINNED_CORE**

**SR_OUTPUT_RB_SIZE**

**INPUT_ORDER_DEFAULT**()

**DEFAULT_RECORDER_SR_CFG**()

### Type Definitions

**typedef** void ***recorder_sr_handle_t**
SR processor handle.

### Header File

- audio_recorder/include/recorder_encoder.h

### Functions

*recorder_encoder_handle_t* **recorder_encoder_create**(*recorder_encoder_cfg_t* **cfg*, recorder_encoder_iface_t ***iface*)
Initialize encoder processor, and the encoder is disabled as default.

**Return** NULL failed Others encoder handle

**Parameters**

- `cfg`: Configuration of encoder
- `iface`: User interface provide by recorder encoder

esp_err_t **recorder_encoder_destroy**(*recorder_encoder_handle_t handle*)
Destroy encoder processor and recycle all resource.

**Return** ESP_OK ESP_FAIL

**Parameters**

- `handle`: Encoder processor handle

### Structures

**struct recorder_encoder_cfg_t**
recorder encoder configuration parameters

#### Public Members

*audio_element_handle_t* **resample**
Handle of resample

*audio_element_handle_t* **encoder**
Handle of encoder

### Type Definitions

**typedef** void ***recorder_encoder_handle_t**
encoder handle

## 2.8 Peripherals

There are several peripherals available in the ESP-ADF, ranging from buttons and LEDs to SD Card or Wi-Fi. The peripherals are implemented using common API that is then expanded with peripheral specific functionality. The following description covers common functionality.

### 2.8.1 ESP Peripherals

This library simplifies the management of peripherals, by pooling and monitoring in a single task, adding basic functions to send and receive events. And it also provides APIs to easily integrate new peripherals.

---

**Note:** Note that if you do not intend to integrate new peripherals into esp_peripherals, you are only interested in simple api `esp_periph_init`, `esp_periph_start`, `esp_periph_stop` and `esp_periph_destroy`. If you want to integrate new peripherals, please refer to *Periph Button* source code

---

#### Examples

Please refer to player/pipeline_http_mp3/main/play_http_mp3_example.c.

#### API Reference

#### Header File

- esp_peripherals/include/esp_peripherals.h

#### Functions

*esp_periph_set_handle_t* **esp_periph_set_init**(*esp_periph_config_t* **config*)
Initialize esp_peripheral sets, create empty peripherals list. Call this function before starting any peripherals (with `esp_periph_start`). This call will initialize the data needed for esp_peripherals to work, but does not actually create the task. The `event_handle` is optional if you want to receive events from this callback function. The esp_peripherals task will send all events out to event_iface, can be listen by event_iface by `esp_periph_get_event_iface`. The `user_context` will sent `esp_periph_event_handle_t` as *context parameter.

**Return** The peripheral sets instance

**Parameters**

- `[in] config`: The configurations

esp_err_t **esp_periph_set_destroy** (*esp_periph_set_handle_t periph_set_handle*)

This function will stop and kill the monitor task, calling all destroy callback functions of the peripheral (so you do not need to destroy the peripheral object manually). It will also remove all memory allocated to the peripherals list, so you need to call the `esp_periph_set_init` function again if you want to use it.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance

esp_err_t **esp_periph_set_stop_all** (*esp_periph_set_handle_t periph_set_handle*)

Stop monitoring all peripherals, the peripheral state is still kept. This funciton only temporary disables the peripheral.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance

*esp_periph_handle_t* **esp_periph_set_get_by_id** (*esp_periph_set_handle_t periph_set_handle*, int *periph_id*)

Get the peripheral handle by Peripheral ID.

**Return** The esp_periph_handle_t

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance
- `[in] periph_id`: as esp_periph_id_t, or any ID you use when calling `esp_periph_create`

*audio_event_iface_handle_t* **esp_periph_set_get_event_iface** (*esp_periph_set_handle_t periph_set_handle*)

Return the event_iface used by this esp_peripherals.

**Return** The audio event iface handle

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance

esp_err_t **esp_periph_set_register_callback** (*esp_periph_set_handle_t periph_set_handle*, *esp_periph_event_handle_t cb*, void **user_context*)

Register peripheral sets event callback function.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance
- `cb`: The event handle callback function
- `user_context`: The user context pointer

QueueHandle_t **esp_periph_set_get_queue** (*esp_periph_set_handle_t periph_set_handle*)

Peripheral is using event_iface to control the event, all events are send out to event_iface queue. This function will be useful in case we want to read events directly from the event_iface queue.

**Return** The queue handle

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance

esp_err_t **esp_periph_set_list_init** (*esp_periph_set_handle_t periph_set_handle*)

Call this function to initialize all the listed peripherals.

**Note** Work with no task peripheral set only

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance

esp_err_t **esp_periph_set_list_run** (*esp_periph_set_handle_t periph_set_handle*, *audio_event_iface_msg_t msg*)

Call this function to run all the listed peripherals.

**Note** Work with no task peripheral set only

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance
- `msg`: The *audio_event_iface_msg_t* handle message

esp_err_t **esp_periph_set_list_destroy** (*esp_periph_set_handle_t periph_set_handle*)

Call this function to destroy all the listed peripherals.

**Note** Work with no task peripheral set only

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance esp_err_t **esp_periph_remove_from_set** (*esp_periph_set_handle_t periph_set_handle*, *esp_periph_handle_t periph*)

Call this function to remove periph from periph_set.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance
- `periph`: The esp_periph_handle_t instance

esp_err_t **esp_periph_alloc_periph_id** (*esp_periph_set_handle_t periph_set_handle*, int **periph_id*)

Allocated a peripheral ID from the periph_set.

**Note** This function can apply for a peripheral ID to realize a customized peripheral module. The requested peripheral ID will not be included in `esp_periph_id_t`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph_set_handle`: The esp_periph_set_handle_t instance
- `[out] periph_id`: The peripheral identifier

esp_err_t **esp_periph_set_change_waiting_time** (*esp_periph_set_handle_t periph_set_handle*, int *time_ms*)

Call this function to change periph_set waiting time.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph_set_handle`: The esp_periph_set_handle_t instance
- `time_ms`: The waiting time

*esp_periph_handle_t* **esp_periph_create** (int *periph_id*, **const** char **tag*)

Call this function to initialize a new peripheral.

**Return** The peripheral handle

**Parameters**

- `[in] periph_id`: The periph identifier
- `[in] tag`: The tag name, we named it easy to get in debug logs

esp_err_t **esp_periph_set_function**(*esp_periph_handle_t periph*, *esp_periph_func init*, *esp_periph_run_func run*, *esp_periph_func destroy*)

Each peripheral has a cycle of sequential operations from initialization, execution of commands to destroying the peripheral. These operations are represented by functions passed as call parameters to this function.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph
- `[in] init`: The initialize
- `[in] run`: The run
- `[in] destroy`: The destroy

esp_err_t **esp_periph_start**(*esp_periph_set_handle_t periph_set_handle*, *esp_periph_handle_t periph*)

Add the peripheral to peripherals list, enable and start monitor task (if task stack size > 0)

**Note** This peripheral must be first created by calling `esp_periph_create`

**Return**

- ESP_OK on success
- ESP_FAIL when any errors

**Parameters**

- `[in] periph_set_handle`: The esp_periph_set_handle_t instance
- `[in] periph`: The peripheral instance

esp_err_t **esp_periph_stop**(*esp_periph_handle_t periph*)

Stop monitoring the peripheral, the peripheral state is still kept. This funciton only temporary disables the peripheral.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph

esp_err_t **esp_periph_send_cmd**(*esp_periph_handle_t periph*, int *cmd*, void **data*, int *data_len*)

When this function is called, the command is passed to the event_iface command queue, and the `esp_periph_run_func` of this peripheral will be executed in the main peripheral task. This function can be called from any task, basically it only sends a queue to the main peripheral task.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph
- `[in] cmd`: The command
- `data`: The data
- `[in] data_len`: The data length

esp_err_t **esp_periph_send_cmd_from_isr** (*esp_periph_handle_t periph*, int *cmd*, void **data*, int *data_len*)

Similar to `esp_periph_send_cmd`, but it can be called in the hardware interrupt handle.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph
- `[in] cmd`: The command
- `data`: The data
- `[in] data_len`: The data length

esp_err_t **esp_periph_send_event** (*esp_periph_handle_t periph*, int *event_id*, void **data*, int *data_len*)

In addition to sending an event via event_iface, this function will dispatch the `event_handle` callback if the event_handle callback is provided at `esp_periph_init`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The peripheral
- `[in] event_id`: The event identifier
- `data`: The data
- `[in] data_len`: The data length

esp_err_t **esp_periph_start_timer** (*esp_periph_handle_t periph*, TickType_t *interval_tick*, *timer_callback callback*)

Each peripheral can initialize a timer, which is by default NULL. When this function is called, the timer for the peripheral is created and it invokes the callback function every interval tick.

**Note**

- You do not need to stop or destroy the timer, when the `esp_periph_destroy` function is called, it will stop and destroy all
- This timer using FreeRTOS Timer, with autoreload = true

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The peripheral
- `[in] interval_tick`: The interval tick
- `[in] callback`: The callback

esp_err_t **esp_periph_stop_timer**(*esp_periph_handle_t periph*)
Stop peripheral timer.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The peripheral

esp_err_t **esp_periph_set_data**(*esp_periph_handle_t periph*, void **data*)
Set the user data.

**Note** Make sure the `data` lifetime is sufficient, this function does not copy all data, it only stores the data pointer

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The peripheral
- `data`: The data

void ***esp_periph_get_data**(*esp_periph_handle_t periph*)
Get the user data stored in the peripheral.

**Return** Peripheral data pointer

**Parameters**

- `[in] periph`: The peripheral

*esp_periph_state_t* **esp_periph_get_state**(*esp_periph_handle_t periph*)
Get the current state of peripheral.

**Return** The peripharal working state

**Parameters**

- `[in] periph`: The handle of peripheral

*esp_periph_id_t* **esp_periph_get_id**(*esp_periph_handle_t periph*)
Get Peripheral identifier.

**Return** The peripheral identifier

**Parameters**

- `[in] periph`: The peripheral

esp_err_t **esp_periph_set_id** (*esp_periph_handle_t periph*, *esp_periph_id_t periph_id*)
Set Peripheral identifier.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The peripheral
- `[in] periph_id`: The peripheral identifier

esp_err_t **esp_periph_init** (*esp_periph_handle_t periph*)
Call this to execute `init` function of peripheral instance.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph`: The peripheral handle

esp_err_t **esp_periph_run** (*esp_periph_handle_t periph*)
Call this to execute `run` function of peripheral instance.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph`: The peripheral handle

esp_err_t **esp_periph_destroy** (*esp_periph_handle_t periph*)
Call this to execute `destroy` function of peripheral instance.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `periph`: The peripheral handle

esp_err_t **esp_periph_register_on_events** (*esp_periph_handle_t periph*, *esp_periph_event_t *evts*)
Rigster peripheral on event handle.

**Return**

- ESP_OK

- ESP_FAIL

**Parameters**

- `periph`: The peripheral handle
- `evts`: The esp_periph_event_t handle

## Structures

**`struct esp_periph_config_t`**

Common peripherals configurations.

### Public Members

int **`task_stack`**

>0 Service task stack size; =0 without task created

int **`task_prio`**

Service task priority (based on freeRTOS priority)

int **`task_core`**

Service task running in core (0 or 1)

bool **`extern_stack`**

Service task stack allocate on extern ram

**`struct esp_periph_event`**

peripheral events

### Public Members

void ***`user_ctx`**

peripheral context data

*esp_periph_event_handle_t* **`cb`**

peripheral callback function

*audio_event_iface_handle_t* **`iface`**

peripheral event

## Macros

**`DEFAULT_ESP_PERIPH_STACK_SIZE`**

**`DEFAULT_ESP_PERIPH_TASK_PRIO`**

**`DEFAULT_ESP_PERIPH_TASK_CORE`**

**`DEFAULT_ESP_PERIPH_SET_CONFIG`**`()`

**`periph_tick_get`**

### Type Definitions

**typedef struct** esp_periph_sets ***esp_periph_set_handle_t**

**typedef struct** esp_periph ***esp_periph_handle_t**

**typedef** esp_err_t (***esp_periph_func**) (*esp_periph_handle_t* periph)

**typedef** esp_err_t (***esp_periph_run_func**) (*esp_periph_handle_t* periph, *audio_event_iface_msg_t* *msg)

**typedef** esp_err_t (***esp_periph_event_handle_t**) (*audio_event_iface_msg_t* *event, void *context)

**typedef** void (***timer_callback**) (xTimerHandle tmr)

**typedef struct** *esp_periph_event* **esp_periph_event_t**
peripheral events

### Enumerations

**enum esp_periph_id_t**
Peripheral Identify, this must be unique for each peripheral added to the peripherals list.

*Values:*

**PERIPH_ID_BUTTON** = *AUDIO_ELEMENT_TYPE_PERIPH* + 1

**PERIPH_ID_TOUCH** = *AUDIO_ELEMENT_TYPE_PERIPH* + 2

**PERIPH_ID_SDCARD** = *AUDIO_ELEMENT_TYPE_PERIPH* + 3

**PERIPH_ID_WIFI** = *AUDIO_ELEMENT_TYPE_PERIPH* + 4

**PERIPH_ID_FLASH** = *AUDIO_ELEMENT_TYPE_PERIPH* + 5

**PERIPH_ID_AUXIN** = *AUDIO_ELEMENT_TYPE_PERIPH* + 6

**PERIPH_ID_ADC** = *AUDIO_ELEMENT_TYPE_PERIPH* + 7

**PERIPH_ID_CONSOLE** = *AUDIO_ELEMENT_TYPE_PERIPH* + 8

**PERIPH_ID_BLUETOOTH** = *AUDIO_ELEMENT_TYPE_PERIPH* + 9

**PERIPH_ID_LED** = *AUDIO_ELEMENT_TYPE_PERIPH* + 10

**PERIPH_ID_SPIFFS** = *AUDIO_ELEMENT_TYPE_PERIPH* + 11

**PERIPH_ID_ADC_BTN** = *AUDIO_ELEMENT_TYPE_PERIPH* + 12

**PERIPH_ID_IS31FL3216** = *AUDIO_ELEMENT_TYPE_PERIPH* + 13

**PERIPH_ID_GPIO_ISR** = *AUDIO_ELEMENT_TYPE_PERIPH* + 14

**PERIPH_ID_WS2812** = *AUDIO_ELEMENT_TYPE_PERIPH* + 15

**PERIPH_ID_AW2013** = *AUDIO_ELEMENT_TYPE_PERIPH* + 16

**PERIPH_ID_LCD** = *AUDIO_ELEMENT_TYPE_PERIPH* + 17

**PERIPH_ID_CUSTOM_BASE** = *AUDIO_ELEMENT_TYPE_PERIPH* + 18

**enum esp_periph_state_t**
Peripheral working state.

*Values:*

**PERIPH_STATE_NULL**

**PERIPH_STATE_INIT**

**PERIPH_STATE_RUNNING**

**PERIPH_STATE_PAUSE**

**PERIPH_STATE_STOPPING**

**PERIPH_STATE_ERROR**

**PERIPH_STATE_STATUS_MAX**

The peripheral specific functionality is available by calling dedicated functions described below. Some peripherals are available on both *ESP32-LyraT* and *ESP32-LyraTD-MSC* development boards, some on a specific board only. The following table provides all implemented peripherals broken down by development board.

## 2.8.2 Wi-Fi Peripheral

The Wi-Fi Peripheral is used to configure Wi-Fi connections, provide APIs to control Wi-Fi connection configuration, as well as monitor the status of Wi-Fi networks.

### Application Example

Implementation of this API is demonstrated in player/pipeline_http_mp3 example.

### API Reference

### Header File

- esp_peripherals/include/periph_wifi.h

### Functions

*esp_periph_handle_t* **periph_wifi_init**(*periph_wifi_cfg_t *config*)

Create the wifi peripheral handle for esp_peripherals.

**Note** The handle was created by this function automatically destroy when `esp_periph_destroy` is called

**Return** The esp peripheral handle

**Parameters**

- `config`: The configuration

esp_err_t **periph_wifi_wait_for_connected**(*esp_periph_handle_t periph*, TickType_t *tick_to_wait*)

This function will block current thread (in `tick_to_wait` tick) and wait until ESP32 connected to the Wi-Fi network, and got ip.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph
- `[in] tick_to_wait`: The tick to wait

*periph_wifi_state_t* **periph_wifi_is_connected**(*esp_periph_handle_t periph*)

Check the Wi-Fi connection status.

**Return** Wi-Fi network status

**Parameters**

- `[in] periph`: The periph

esp_err_t **esp_wifi_set_listen_interval**(*esp_periph_handle_t periph*, int *interval*)

Set Wi-Fi listen interval for ESP32 station to receive beacon.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The wifi periph
- `[in] interval`: listen interval. units: AP beacon intervals(see BcnInt, default: 100ms)

esp_err_t **periph_wifi_config_start**(*esp_periph_handle_t periph*, *periph_wifi_config_mode_t mode*)

Start Wi-Fi network setup in `mode`

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph
- `[in] mode`: The mode

esp_err_t **periph_wifi_config_wait_done**(*esp_periph_handle_t periph*, TickType_t *tick_to_wait*)

Wait for Wi-Fi setup done.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph
- `[in] tick_to_wait`: The tick to wait

### Structures

**struct periph_wpa2_enterprise_cfg_t**
The WPA2 enterprise peripheral configuration.

#### Public Members

bool **diasble_wpa2_e**
Disable wpa2 enterprise

int **eap_method**
TLS: 0, PEAP: 1, TTLS: 2

char ***ca_pem_start**
binary wpa2 ca pem start

char ***ca_pem_end**
binary wpa2 ca pem end

char ***wpa2_e_cert_start**
binary wpa2 cert start

char ***wpa2_e_cert_end**
binary wpa2 cert end

char ***wpa2_e_key_start**
binary wpa2 key start

char ***wpa2_e_key_end**
binary wpa2 key end

**const** char ***eap_id**
Identity in phase 1 of EAP procedure

**const** char ***eap_username**
Username for EAP method (PEAP and TTLS)

**const** char ***eap_password**
Password for EAP method (PEAP and TTLS)

**struct periph_wifi_cfg_t**
The Wi-Fi peripheral configuration.

#### Public Members

bool **disable_auto_reconnect**
Disable Wi-Fi auto reconnect

int **reconnect_timeout_ms**
The reconnect timeout after disconnected from Wi-Fi network

wifi_config_t **wifi_config**
Wifi configure

*periph_wpa2_enterprise_cfg_t* **wpa2_e_cfg**
wpa2 enterprise config

### Enumerations

**enum periph_wifi_state_t**
Peripheral Wi-Fi event id.

*Values:*

**PERIPH_WIFI_UNCHANGE** = 0

**PERIPH_WIFI_CONNECTING**

**PERIPH_WIFI_CONNECTED**

**PERIPH_WIFI_DISCONNECTED**

**PERIPH_WIFI_SETTING**

**PERIPH_WIFI_CONFIG_DONE**

**PERIPH_WIFI_CONFIG_ERROR**

**PERIPH_WIFI_ERROR**

**enum periph_wifi_config_mode_t**
Wi-Fi setup mode type.

*Values:*

**WIFI_CONFIG_ESPTOUCH**
Using smartconfig with ESPTOUCH protocol

**WIFI_CONFIG_AIRKISS**
Using smartconfig with AIRKISS protocol

**WIFI_CONFIG_ESPTOUCH_AIRKISS**
Using smartconfig with ESPTOUCH_AIRKISS protocol

**WIFI_CONFIG_WPS**
Using WPS (not support)

**WIFI_CONFIG_BLUEFI**
Using BLUEFI

**WIFI_CONFIG_WEB**
Using HTTP Server (not support)

## 2.8.3 SD Card Peripheral

If your board has a SD card connected, use this API to initialize, mount and unmount the card, see functions *periph_sdcard_init()*, `periph_sdcard_mount()` and `periph_sdcard_unmount()`. The data reading / writing is implemented in a separate API described in *FatFs Stream*.

### Application Examples

Implementation of this API is demonstrated in couple of examples:

- player/pipeline_play_sdcard_music
- player/pipeline_sdcard_mp3_control
- recorder/pipeline_recording_to_sdcard
- recorder/pipeline_wav_amr_sdcard

### API Reference

### Header File

- esp_peripherals/include/periph_sdcard.h

### Functions

*esp_periph_handle_t* **periph_sdcard_init**(*periph_sdcard_cfg_t *sdcard_config*)

Create the sdcard peripheral handle for esp_peripherals.

**Note** The handle was created by this function automatically destroy when `esp_periph_destroy` is called

**Return** The esp peripheral handle

**Parameters**

- `sdcard_config`: The sdcard configuration

bool **periph_sdcard_is_mounted**(*esp_periph_handle_t periph*)

Check the sdcard is mounted or not.

**Return** SDCARD mounted state

**Parameters**

- `[in] periph`: The periph

### Structures

**struct periph_sdcard_cfg_t**

The SD Card Peripheral configuration.

### Public Members

int **card_detect_pin**
Card detect gpio number

**const** char ***root**
Base path for vfs

*periph_sdcard_mode_t* **mode**
card mode

## Enumerations

**enum periph_sdcard_event_id_t**
Peripheral sdcard event id.

*Values:*

**SDCARD_STATUS_UNKNOWN**
No event

**SDCARD_STATUS_CARD_DETECT_CHANGE**
Detect changes in the card_detect pin

**SDCARD_STATUS_MOUNTED**
SDCARD mounted successfully

**SDCARD_STATUS_UNMOUNTED**
SDCARD unmounted successfully

**SDCARD_STATUS_MOUNT_ERROR**
SDCARD mount error

**SDCARD_STATUS_UNMOUNT_ERROR**
SDCARD unmount error

**enum periph_sdcard_mode_t**
SD card mode, SPI, 1-line SD mode, 4-line SD mode.

*Values:*

**SD_MODE_SPI** = 0x0
sd_card SPI

**SD_MODE_1_LINE** = 0x1
sd_card 1-line SD mode

**SD_MODE_4_LINE** = 0x4
sd_card 4-line SD mode

**SD_MODE_8_LINE** = 0x8
sd_card 8-line SD mode

**SD_MODE_MAX**

### 2.8.4 Spiffs Peripheral

Use this API to initialize, mount and unmount spiffs partition, see functions *periph_spiffs_init()*, `periph_spiffs_mount()` and `periph_spiffs_unmount()`. The data reading / writing is implemented in a separate API described in *SPIFFS Stream*.

#### Application Example

Implementation of this API is demonstrated in audio_processing/pipeline_spiffs_amr_resample example.

#### API Reference

#### Header File

- esp_peripherals/include/periph_spiffs.h

#### Functions

*esp_periph_handle_t* **periph_spiffs_init** (*periph_spiffs_cfg_t *spiffs_config*)

Create the spiffs peripheral handle for esp_peripherals.

**Note** The handle created by this function will be automatically destroyed when `esp_periph_destroy` is called

**Return** The esp peripheral handle

**Parameters**

- `spiffs_config`: The spiffs configuration

bool **periph_spiffs_is_mounted** (*esp_periph_handle_t periph*)

Check if the SPIFFS is mounted or not.

**Return** SPIFFS mounted state

**Parameters**

- `[in] periph`: The periph

#### Structures

**struct periph_spiffs_cfg_t**

The SPIFFS Peripheral configuration.

#### Public Members

**const** char ***root**
Base path for vfs

**const** char ***partition_label**
Optional, label of SPIFFS partition to use. If set to NULL, first partition with subtype=spiffs will be used.

size_t **max_files**
Maximum number of files that could be open at the same time.

bool **format_if_mount_failed**
If true, it will format the file system if it fails to mount.

### Enumerations

**enum periph_spiffs_event_id_t**
Peripheral spiffs event id.

*Values:*

**SPIFFS_STATUS_UNKNOWN**
No event

**SPIFFS_STATUS_MOUNTED**
SPIFFS mounted successfully

**SPIFFS_STATUS_UNMOUNTED**
SPIFFS unmounted successfully

**SPIFFS_STATUS_MOUNT_ERROR**
SPIFFS mount error

**SPIFFS_STATUS_UNMOUNT_ERROR**
SPIFFS unmount error

## 2.8.5 Console Peripheral

Console Peripheral is used to control the Audio application from the terminal screen. It provides 2 ways do execute command, one sends an event to esp_peripherals (for a command without parameters), another calls a callback function (need parameters). If there is a callback function, no event will be sent.

Please make sure that the lifetime of *periph_console_cmd_t* must be ensured during console operation, *periph_console_init()* only reference, does not make a copy.

### Code example

Please refer to cli/main/console_example.c.

### API Reference

#### Header File

- esp_peripherals/include/periph_console.h

#### Functions

*esp_periph_handle_t* **periph_console_init** (*periph_console_cfg_t *config*)
Initialize Console Peripheral.

**Return** The esp peripheral handle

**Parameters**

- `config`: The configuration

#### Structures

**struct periph_console_cmd_t**
Command structure.

##### Public Members

`const` char ***cmd**
Name of command, must be unique

int **id**
Command ID will be sent together when the command is matched

`const` char ***help**
Explanation of the command

*console_cmd_callback_t* **func**
Function callback for the command

**struct periph_console_cfg_t**
Console Peripheral configuration.

##### Public Members

int **command_num**
Total number of commands

`const` *periph_console_cmd_t* ***commands**
Pointer to array of commands

int **task_stack**
Console task stack, using default if the value is zero

int **task_prio**
Console task priority (based on freeRTOS priority), using default if the value is zero

int **buffer_size**
Size of console input buffer

**const** char ***prompt_string**
Console prompt string, using default CONSOLE_PROMPT_STRING if the pointer is NULL

### Macros

**CONSOLE_DEFAULT_TASK_PRIO**

**CONSOLE_DEFAULT_TASK_STACK**

**CONSOLE_DEFAULT_BUFFER_SIZE**

**CONSOLE_DEFAULT_PROMPT_STRING**

### Type Definitions

**typedef** esp_err_t (***console_cmd_callback_t**)(*esp_periph_handle_t* periph, int argc, char *argv[])

## 2.8.6 Touch Peripheral

Initialize ESP32 touchpad peripheral and retrieve information from the touch sensors.

### Application Example

Implementation of this API is demonstrated in get-started/play_mp3_control example.

### API Reference

### Header File

- esp_peripherals/include/periph_touch.h

### Functions

*esp_periph_handle_t* **periph_touch_init**(*periph_touch_cfg_t* **config*)
Create the touch peripheral handle for esp_peripherals.

**Note** The handle was created by this function automatically destroy when `esp_periph_destroy` is called

**Return** The esp peripheral handle

**Parameters**

- `config`: The configuration

### Structures

**struct periph_touch_cfg_t**
The Touch peripheral configuration.

#### Public Members

int **touch_mask**
Touch pad mask using for this Touch peripheral, ex: TOUCH_PAD_SEL0 | TOUCH_PAD_SEL1

int **tap_threshold_percent**
Tap threshold percent, Tap event will be determined if the percentage value is less than the non-touch value

int **long_tap_time_ms**
Long tap duration in milliseconds, default is 2000ms, PERIPH_TOUCH_LONG_TAP will be occurred if TAP and time hold longer than this value

### Enumerations

**enum esp_touch_pad_sel_t**
Touch pad selection.

*Values:*

**TOUCH_PAD_SEL0** = BIT(0)

**TOUCH_PAD_SEL1** = BIT(1)

**TOUCH_PAD_SEL2** = BIT(2)

**TOUCH_PAD_SEL3** = BIT(3)

**TOUCH_PAD_SEL4** = BIT(4)

**TOUCH_PAD_SEL5** = BIT(5)

**TOUCH_PAD_SEL6** = BIT(6)

**TOUCH_PAD_SEL7** = BIT(7)

**TOUCH_PAD_SEL8** = BIT(8)

**TOUCH_PAD_SEL9** = BIT(9)

**enum periph_touch_event_id_t**
Peripheral touch event id.

*Values:*

**PERIPH_TOUCH_UNCHANGE** = 0
No event

**PERIPH_TOUCH_TAP**
When touch pad is tapped

**PERIPH_TOUCH_RELEASE**
When touch pad is released after tap

**PERIPH_TOUCH_LONG_TAP**
When touch pad is tapped and held after `long_tap_time_ms` time

**PERIPH_TOUCH_LONG_RELEASE**
When touch pad is released after long tap

## 2.8.7 Button Peripheral

To control application flow you may use buttons connected and read through the ESP32 GPIOs. This API provides functions to initialize specific GPIOs and obtain information on button events such as when it has been pressed, when released, when pressed for a long time and released after long press. To get information on a particular event, establish a callback function with `button_dev_add_tap_cb()` or `button_dev_add_press_cb()`.

### Application Example

Implementation of this API is demonstrated in cloud_services/google_translate_device example.

### API Reference

### Header File

- esp_peripherals/include/periph_button.h

### Functions

*esp_periph_handle_t* **periph_button_init**(*periph_button_cfg_t* **but_cfg*)
Create the button peripheral handle for esp_peripherals.

**Note** The handle was created by this function automatically destroy when `esp_periph_destroy` is called

**Return** The esp peripheral handle

**Parameters**

- `but_cfg`: The but configuration

### Structures

**struct periph_button_cfg_t**
The Button peripheral configuration.

#### Public Members

uint64_t **gpio_mask**
GPIO Mask using for this Button peripheral, it is BIT(GPIO_NUM), ex: GPIO_SEL_36 | GPIO_SEL_36

int **long_press_time_ms**
Long press duration in milliseconds, default is 2000ms

### Enumerations

**enum periph_button_event_id_t**
Peripheral button event id.

*Values:*

**PERIPH_BUTTON_UNCHANGE** = 0
No event

**PERIPH_BUTTON_PRESSED**
When button is pressed

**PERIPH_BUTTON_RELEASE**
When button is released

**PERIPH_BUTTON_LONG_PRESSED**
When button is pressed and kept for more than `long_press_time_ms`

**PERIPH_BUTTON_LONG_RELEASE**
When button is released and event PERIPH_BUTTON_LONG_PRESSED happened

## 2.8.8 LED Peripheral

Blink or fade a LED connected to a GPIO with configurable On and Off times.

### Application Examples

Implementation of this API is demonstrated in couple of examples:

- /cloud_services/google_translate_device
- /dueros

### API Reference

### Header File

- esp_peripherals/include/periph_led.h

### Functions

*esp_periph_handle_t* **periph_led_init**(*periph_led_cfg_t *config*)
Create the LED peripheral handle for esp_peripherals.

**Note** The handle was created by this function automatically destroy when `esp_periph_destroy` is called

**Return** The esp peripheral handle

**Parameters**

- `config`: The configuration

esp_err_t **periph_led_blink**(*esp_periph_handle_t periph*, int *gpio_num*, int *time_on_ms*, int *time_off_ms*, bool *fade*, int *loop*, *periph_led_idle_level_t level*)

Bink LED Peripheral, this function will automatically configure the gpio_num to control the LED, with `time_on_ms` as the time (in milliseconds) switch from OFF to ON (or ON if fade is disabled), and `time_off_ms` as the time (in milliseconds) switch from ON to OFF (or OFF if fade is disabled). When switching from ON -> OFF and vice versa, the loop decreases once, and will turn off the effect when the loop is 0. With a loop value less than 0, the LED effect will loop endlessly. PERIPH_LED_BLINK_FINISH events will be sent at each end of loop.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The LED periph
- `[in] gpio_num`: The gpio number
- `[in] time_on_ms`: The time on milliseconds
- `[in] time_off_ms`: The time off milliseconds
- `[in] fade`: Fading enabled
- `[in] loop`: Loop
- `[in] level`: idle level

esp_err_t **periph_led_stop**(*esp_periph_handle_t periph*, int *gpio_num*)

Stop Blink the LED.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] periph`: The periph
- `[in] gpio_num`: The gpio number

## Structures

**struct periph_led_cfg_t**

The LED peripheral configuration.

#### Public Members

ledc_mode_t **led_speed_mode**
LEDC speed speed_mode, high-speed mode or low-speed mode

ledc_timer_bit_t **led_duty_resolution**
LEDC channel duty resolution

ledc_timer_t **led_timer_num**
Select the timer source of channel (0 - 3)

uint32_t **led_freq_hz**
LEDC timer frequency (Hz)

int **gpio_num**
Optional, < 0 invalid gpio number

### Enumerations

**enum periph_led_event_id_t**
Peripheral LED event id.

*Values:*

**PERIPH_LED_UNCHANGE** = 0
No event

**PERIPH_LED_BLINK_FINISH**
When LED blink is finished

**enum periph_led_idle_level_t**
Peripheral LED idle output level.

*Values:*

**PERIPH_LED_IDLE_LEVEL_LOW**
Low level output

**PERIPH_LED_IDLE_LEVEL_HIGH**
High level output

## 2.8.9 ADC Button Peripheral

Read status of buttons connected to an ADC input using a resistor ladder. Configuration provides for more than a singe ADC input to read several sets of buttons. For an example hardware implementation please refer to schematic of ESP32-LyraTD-MSC V2.2 Upper Board (PDF).

### Application Examples

Implementation of this API is demonstrated in the following example:

- checks/check_board_buttons

### API Reference

### Header File

- esp_peripherals/include/periph_adc_button.h

### Functions

*esp_periph_handle_t* **periph_adc_button_init**(*periph_adc_button_cfg_t *btn_cfg*)

Create the button peripheral handle for esp_peripherals.

**Note** The handle created by this function is automatically destroyed when esp_periph_destroy is called.

**Return** The esp peripheral handle.

**Parameters**

- `btn_cfg`: The button configuration.

### Structures

**struct periph_adc_button_cfg_t**

The configuration of ADC Button.

#### Public Members

adc_arr_t ***arr**

An array with configuration of buttons

int **arr_size**

The array size

adc_btn_task_cfg_t **task_cfg**

Adc button task configuration

### Macros

**ADC_BUTTON_STACK_SIZE**

**ADC_BUTTON_TASK_PRIORITY**

**ADC_BUTTON_TASK_CORE_ID**

**PERIPH_ADC_BUTTON_DEFAULT_CONFIG**()

**ADC_DEFAULT_ARR**()
ESP32 ADC1 channels and GPIO table ADC1_CHANNEL_0 - GPIO36 ADC1_CHANNEL_1 - GPIO37 ADC1_CHANNEL_2 - GPIO38 ADC1_CHANNEL_3 - GPIO39 ADC1_CHANNEL_4 - GPIO32 ADC1_CHANNEL_5 - GPIO33 ADC1_CHANNEL_6 - GPIO34 ADC1_CHANNEL_7 - GPIO35

### Enumerations

**enum periph_adc_button_event_id_t**
*Values:*

**PERIPH_ADC_BUTTON_IDLE** = 0

**PERIPH_ADC_BUTTON_PRESSED**

**PERIPH_ADC_BUTTON_RELEASE**

**PERIPH_ADC_BUTTON_LONG_PRESSED**

**PERIPH_ADC_BUTTON_LONG_RELEASE**

## 2.8.10 LED Controller Peripheral

This peripheral is applicable to IS31Fl3216 chip that is a light LED controller with an audio modulation mode. It can store data of 8 Frames with internal RAM to play small animations automatically. You can also use it to control a number of LEDs connected to GPIOs. If you want to use the IS31Fl3216, see functions *periph_is31fl3216_init()*, *periph_is31fl3216_set_blink_pattern()*, *periph_is31fl3216_set_duty()*, *periph_is31fl3216_set_state()*.

### Application Examples

Implementation of this API is demonstrated in checks/check_display_led example.

### API Reference

### Header File

- esp_peripherals/include/periph_is31fl3216.h

### Functions

*esp_periph_handle_t* **periph_is31fl3216_init**(*periph_is31fl3216_cfg_t *is31fl3216_config*)
Initializate the is31fl3216.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `is31fl3216_config`:

esp_err_t **periph_is31fl3216_set_state** (*esp_periph_handle_t periph*, *periph_is31fl3216_state_t state*)

Set the state of all the channels.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `periph`: The is31fl3216 handle
- `state`: The state of all channels

esp_err_t **periph_is31fl3216_set_blink_pattern** (*esp_periph_handle_t periph*, uint16_t *blink_pattern*)

Set the current enable channels.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `periph`: The is31fl3216 handle
- `blink_pattern`: The bit pattern of enabled channels

esp_err_t **periph_is31fl3216_set_duty** (*esp_periph_handle_t periph*, uint8_t *index*, uint8_t *value*)

Set the duty of the channel.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `periph`: The is31fl3216 handle
- `index`: The channel number
- `value`: The value of the channel's duty to be set

esp_err_t **periph_is31fl3216_set_duty_step** (*esp_periph_handle_t periph*, uint8_t *step*)

Set the duty step of flash.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `periph`: The is31fl3216 handle
- `step`: The step of flash

esp_err_t **periph_is31fl3216_set_interval** (*esp_periph_handle_t periph*, uint16_t *interval_ms*)

Set the internval time.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `periph`: The is31fl3216 handle
- `interval_ms`: Time of interval

esp_err_t **periph_is31fl3216_set_shift_mode** (*esp_periph_handle_t periph*, *periph_is31_shift_mode_t mode*)

Set the shift mode.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `periph`: The is31fl3216 handle
- `mode`: Mode of periph_is31_shift_mode_t

esp_err_t **periph_is31fl3216_set_light_on_num** (*esp_periph_handle_t periph*, uint16_t *light_on_num*, uint16_t *max_light_num*)

Set the light on numbers.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `periph`: The is31fl3216 handle
- `light_on_num`: Enabled led number
- `max_light_num`: Maximum led number

esp_err_t **periph_is31fl3216_set_act_time** (*esp_periph_handle_t periph*, uint16_t *act_ms*)

Set the action time.

**Return**

- ESP_OK Success
- ESP_FAIL Fail

**Parameters**

- `periph`: The is31fl3216 handle
- `act_ms`: Action time, unit is millisecond, 0 is infinite

### Structures

**struct periph_is31fl3216_cfg_t**
The configuration of is31fl3216.

#### Public Members

uint32_t **duty**[**IS31FL3216_CH_NUM**]
An array of the is31fl3216's duty

uint16_t **is31fl3216_pattern**
Current enable channel

*periph_is31fl3216_state_t* **state**
The state of all the channels

### Macros

**IS31FL3216_CH_NUM**

**BLUE_LED_MAX_NUM**

### Enumerations

**enum periph_is31fl3216_state_t**
*Values:*

**IS31FL3216_STATE_UNKNOWN**

**IS31FL3216_STATE_OFF**

**IS31FL3216_STATE_ON**

**IS31FL3216_STATE_FLASH**

**IS31FL3216_STATE_BY_AUDIO**

**IS31FL3216_STATE_SHIFT**

**enum periph_is31_shift_mode_t**
*Values:*

**PERIPH_IS31_SHIFT_MODE_UNKNOWN**

**PERIPH_IS31_SHIFT_MODE_ACC**
accumulation mode

**PERIPH_IS31_SHIFT_MODE_SINGLE**

| Name of Peripheral | ESP32-LyraT | ESP32-LyraTD-MSC |
|---|---|---|
| *Wi-Fi* | ✓ | ✓ |
| *SD Card* | ✓ | ✓ |
| *Spiffs* | ✓ | ✓ |
| *Console* | ✓ | ✓ |
| *Touch* | ✓ | |
| *Button* | ✓ | |
| *LED* | ✓ | |
| *ADC Button* | | ✓ |
| *LED Controller* | | ✓ |

## 2.9 Abstraction Layer

### 2.9.1 Ring Buffer

Ringbuffer is designed in addition to use as a data buffer, also used to connect Audio Elements. Each Element that requests data from the Ringbuffer will block the task until the data is available. Or block the task when writing data and the Buffer is full. Of course, we can stop this block at any time.


Fig. 7: Ring Buffer used in Audio Pipeline

### Application Example

In most of ESP-ADF examples connecting of Elements with Ringbuffers is done "behind the scenes" by a function `audio_pipeline_link()`. To see this operation exposed check player/pipeline_sdcard_mp3_control example.

### API Reference

### Header File

- audio_pipeline/include/ringbuf.h

### Functions

*ringbuf_handle_t* **rb_create** (int *block_size*, int *n_blocks*)
Create ringbuffer with total size = block_size * n_blocks.

**Return** ringbuf_handle_t

**Parameters**

- `[in] block_size`: Size of each block
- `[in] n_blocks`: Number of blocks

esp_err_t **rb_destroy** (*ringbuf_handle_t rb*)
Cleanup and free all memory created by ringbuf_handle_t.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle

esp_err_t **rb_abort** (*ringbuf_handle_t rb*)
Abort waiting until there is space for reading or writing of the ringbuffer.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle

esp_err_t **rb_reset** (*ringbuf_handle_t rb*)
Reset ringbuffer, clear all values as initial state.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle

esp_err_t **`rb_reset_is_done_write`**(*ringbuf_handle_t rb*)

Reset is_done_write flag.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle

int **`rb_bytes_available`**(*ringbuf_handle_t rb*)

Get total bytes available of Ringbuffer.

**Return** total bytes available

**Parameters**

- `[in] rb`: The Ringbuffer handle

int **`rb_bytes_filled`**(*ringbuf_handle_t rb*)

Get the number of bytes that have filled the ringbuffer.

**Return** The number of bytes that have filled the ringbuffer

**Parameters**

- `[in] rb`: The Ringbuffer handle

int **`rb_get_size`**(*ringbuf_handle_t rb*)

Get total size of Ringbuffer (in bytes)

**Return** total size of Ringbuffer

**Parameters**

- `[in] rb`: The Ringbuffer handle

int **`rb_read`**(*ringbuf_handle_t rb*, char **buf*, int *len*, TickType_t *ticks_to_wait*)

Read from Ringbuffer to `buf` with len and wait `tick_to_wait` ticks until enough bytes to read if the ringbuffer bytes available is less than `len`. If `buf` argument provided is `NULL`, then ringbuffer do pseudo reads by simply advancing pointers.

**Return** Number of bytes read

**Parameters**

- `[in] rb`: The Ringbuffer handle
- `buf`: The buffer pointer to read out data
- `[in] len`: The length request
- `[in] ticks_to_wait`: The ticks to wait

int **rb_write** (*ringbuf_handle_t rb*, char **buf*, int *len*, TickType_t *ticks_to_wait*)
Write to Ringbuffer from `buf` with `len` and wait `tick_to_wait` ticks until enough space to write if the ringbuffer space available is less than `len`

**Return** Number of bytes written

**Parameters**

- `[in] rb`: The Ringbuffer handle
- `buf`: The buffer
- `[in] len`: The length
- `[in] ticks_to_wait`: The ticks to wait

esp_err_t **rb_done_write** (*ringbuf_handle_t rb*)
Set status of writing to ringbuffer is done.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle

esp_err_t **rb_unblock_reader** (*ringbuf_handle_t rb*)
Unblock from rb_read.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle

esp_err_t **rb_set_reader_holder** (*ringbuf_handle_t rb*, void **holder*)
Set the owner of the 'rb_read'.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle
- `[in] holder`: The owner of the 'rb_read'

esp_err_t **rb_get_reader_holder** (*ringbuf_handle_t rb*, void ***holder*)
Get the owner of the 'rb_read'.

**Return**

- ESP_OK

- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle
- `[out] holder`: The owner of the 'rb_read'

esp_err_t **rb_set_writer_holder** (*ringbuf_handle_t rb*, void **holder*)
Set the owner of the 'rb_write'.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle
- `[in] holder`: The owner of the 'rb_write'

esp_err_t **rb_get_writer_holder** (*ringbuf_handle_t rb*, void ***holder*)
Get the owner of the 'rb_write'.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[in] rb`: The Ringbuffer handle
- `[out] holder`: The owner of the 'rb_write'

### Macros

**RB_OK**

**RB_FAIL**

**RB_DONE**

**RB_ABORT**

**RB_TIMEOUT**

### Type Definitions

**typedef struct** ringbuf ***ringbuf_handle_t**

### 2.9.2 Audio HAL

Abstraction layer for audio board hardware, serves as an interface between the user application and the hardware driver for specific audio board like *ESP32 LyraT*.

The API provides data structures to configure sampling rates of ADC and DAC signal conversion, data bit widths, I2C stream parameters, and selection of signal channels connected to ADC and DAC. It also contains several specific functions to e.g. initialize the audio board, `audio_hal_init()`, control the volume, `audio_hal_get_volume()` and `audio_hal_set_volume()`.

#### API Reference

#### Header File

- audio_hal/include/audio_hal.h

#### Functions

*audio_hal_handle_t* **`audio_hal_init`**(*audio_hal_codec_config_t *audio_hal_conf*, *audio_hal_func_t *audio_hal_func*)

Initialize media codec driver.

**Note** If selected codec has already been installed, it'll return the *audio_hal* handle.

**Return** int, 0success, othersfail

**Parameters**

- `audio_hal_conf`: Configure structure audio_hal_config_t
- `audio_hal_func`: Structure containing functions used to operate audio the codec chip

esp_err_t **`audio_hal_deinit`**(*audio_hal_handle_t audio_hal*)

Uninitialize media codec driver.

**Return** int, 0success, othersfail

**Parameters**

- `audio_hal`: reference function pointer for selected audio codec

esp_err_t **`audio_hal_ctrl_codec`**(*audio_hal_handle_t audio_hal*, *audio_hal_codec_mode_t mode*, *audio_hal_ctrl_t audio_hal_ctrl*)

Start/stop codec driver.

**Return** int, 0success, othersfail

**Parameters**

- `audio_hal`: reference function pointer for selected audio codec
- `mode`: select media hal codec mode either encode/decode/or both to start from audio_hal_codec_mode_t
- `audio_hal_ctrl`: select start stop state for specific mode

esp_err_t **audio_hal_codec_iface_config** (*audio_hal_handle_t audio_hal*, *audio_hal_codec_mode_t mode*, *audio_hal_codec_i2s_iface_t *iface*)

Set codec I2S interface samples rate & bit width and format either I2S or PCM/DSP.

**Return**

- 0 Success
- -1 Error

**Parameters**

- `audio_hal`: reference function pointer for selected audio codec
- `mode`: select media hal codec mode either encode/decode/or both to start from audio_hal_codec_mode_t
- `iface`: I2S sample rate (ex: 16000, 44100), I2S bit width (16, 24, 32),I2s format (I2S, PCM, DSP).

esp_err_t **audio_hal_set_mute** (*audio_hal_handle_t audio_hal*, bool *mute*)

Set voice mute. Enables or disables DAC mute of a codec.

**Note** `audio_hal_get_volume` will still give a non-zero number in mute state. It will be set to that number when speaker is unmuted.

**Return** int, 0success, othersfail

**Parameters**

- `audio_hal`: reference function pointer for selected audio codec
- `mute`: true/false. If true speaker will be muted and if false speaker will be unmuted.

esp_err_t **audio_hal_set_volume** (*audio_hal_handle_t audio_hal*, int *volume*)

Set voice volume.

**Note** if volume is 0, mute is enabled,range is 0-100.

**Return** int, 0success, othersfail

**Parameters**

- `audio_hal`: reference function pointer for selected audio codec
- `volume`: value of volume in percent(%)

esp_err_t **audio_hal_get_volume** (*audio_hal_handle_t audio_hal*, int **volume*)

get voice volume.

**Note** if volume is 0, mute is enabled, range is 0-100.

**Return** int, 0success, othersfail

**Parameters**

- `audio_hal`: reference function pointer for selected audio codec
- `volume`: value of volume in percent returned(%)

esp_err_t **audio_hal_enable_pa** (*audio_hal_handle_t audio_hal*, bool *enable*)

Enables or disables PA.

**Return** int, 0success, othersfail

**Parameters**

- *audio_hal*: reference function pointer for selected audio codec
- enable: true/false.

### Structures

**struct audio_hal_codec_i2s_iface_t**

I2s interface configuration for audio codec chip.

#### Public Members

*audio_hal_iface_mode_t* **mode**

audio codec chip mode

*audio_hal_iface_format_t* **fmt**

I2S interface format

*audio_hal_iface_samples_t* **samples**

I2S interface samples per second

*audio_hal_iface_bits_t* **bits**

i2s interface number of bits per sample

**struct audio_hal_codec_config_t**

Configure media hal for initialization of audio codec chip.

#### Public Members

*audio_hal_adc_input_t* **adc_input**

set adc channel

*audio_hal_dac_output_t* **dac_output**

set dac channel

*audio_hal_codec_mode_t* **codec_mode**

select codec mode: adc, dac or both

*audio_hal_codec_i2s_iface_t* **i2s_iface**

set I2S interface configuration

**struct audio_hal**

Configuration of functions and variables used to operate audio codec chip.

### Public Members

esp_err_t (***audio_codec_initialize**) (*audio_hal_codec_config_t* *codec_cfg)
initialize codec

esp_err_t (***audio_codec_deinitialize**) (void)
deinitialize codec

esp_err_t (***audio_codec_ctrl**) (*audio_hal_codec_mode_t* mode, *audio_hal_ctrl_t* ctrl_state)
control codec mode and state

esp_err_t (***audio_codec_config_iface**) (*audio_hal_codec_mode_t* mode, *audio_hal_codec_i2s_iface_t* *iface)
configure i2s interface

esp_err_t (***audio_codec_set_mute**) (bool mute)
set codec mute

esp_err_t (***audio_codec_set_volume**) (int volume)
set codec volume

esp_err_t (***audio_codec_get_volume**) (int *volume)
get codec volume

esp_err_t (***audio_codec_enable_pa**) (bool enable)
enable pa

xSemaphoreHandle **audio_hal_lock**
semaphore of codec

void ***handle**
handle of audio codec

## Macros

**AUDIO_HAL_VOL_DEFAULT**

## Type Definitions

**typedef struct** *audio_hal* ***audio_hal_handle_t**

**typedef struct** *audio_hal* **audio_hal_func_t**
Configuration of functions and variables used to operate audio codec chip.

## Enumerations

**enum audio_hal_codec_mode_t**
Select media hal codec mode.

*Values:*

**AUDIO_HAL_CODEC_MODE_ENCODE** = 1
select adc

**AUDIO_HAL_CODEC_MODE_DECODE**
select dac

**AUDIO_HAL_CODEC_MODE_BOTH**
select both adc and dac

**AUDIO_HAL_CODEC_MODE_LINE_IN**
set adc channel

**enum audio_hal_adc_input_t**
Select adc channel for input mic signal.

*Values:*

**AUDIO_HAL_ADC_INPUT_LINE1** = 0x00
mic input to adc channel 1

**AUDIO_HAL_ADC_INPUT_LINE2**
mic input to adc channel 2

**AUDIO_HAL_ADC_INPUT_ALL**
mic input to both channels of adc

**AUDIO_HAL_ADC_INPUT_DIFFERENCE**
mic input to adc difference channel

**enum audio_hal_dac_output_t**
Select channel for dac output.

*Values:*

**AUDIO_HAL_DAC_OUTPUT_LINE1** = 0x00
dac output signal to channel 1

**AUDIO_HAL_DAC_OUTPUT_LINE2**
dac output signal to channel 2

**AUDIO_HAL_DAC_OUTPUT_ALL**
dac output signal to both channels

**enum audio_hal_ctrl_t**
Select operating mode i.e. start or stop for audio codec chip.

*Values:*

**AUDIO_HAL_CTRL_STOP** = 0x00
set stop mode

**AUDIO_HAL_CTRL_START** = 0x01
set start mode

**enum audio_hal_iface_mode_t**
Select I2S interface operating mode i.e. master or slave for audio codec chip.

*Values:*

**AUDIO_HAL_MODE_SLAVE** = 0x00
set slave mode

**AUDIO_HAL_MODE_MASTER** = 0x01
set master mode

**enum audio_hal_iface_samples_t**
Select I2S interface samples per second.

*Values:*

**AUDIO_HAL_08K_SAMPLES**
set to 8k samples per second

**AUDIO_HAL_11K_SAMPLES**
set to 11.025k samples per second

**AUDIO_HAL_16K_SAMPLES**
set to 16k samples in per second

**AUDIO_HAL_22K_SAMPLES**
set to 22.050k samples per second

**AUDIO_HAL_24K_SAMPLES**
set to 24k samples in per second

**AUDIO_HAL_32K_SAMPLES**
set to 32k samples in per second

**AUDIO_HAL_44K_SAMPLES**
set to 44.1k samples per second

**AUDIO_HAL_48K_SAMPLES**
set to 48k samples per second

**enum audio_hal_iface_bits_t**
Select I2S interface number of bits per sample.

*Values:*

**AUDIO_HAL_BIT_LENGTH_16BITS** = 1
set 16 bits per sample

**AUDIO_HAL_BIT_LENGTH_24BITS**
set 24 bits per sample

**AUDIO_HAL_BIT_LENGTH_32BITS**
set 32 bits per sample

**enum audio_hal_iface_format_t**
Select I2S interface format for audio codec chip.

*Values:*

**AUDIO_HAL_I2S_NORMAL** = 0
set normal I2S format

**AUDIO_HAL_I2S_LEFT**
set all left format

**AUDIO_HAL_I2S_RIGHT**
set all right format

**AUDIO_HAL_I2S_DSP**
set dsp/pcm format

### 2.9.3 ES8388 Driver

Driver for ES8388 codec chip used in *ESP32 LyraT* audio board.

#### API Reference

#### Header File

- audio_hal/driver/es8388/es8388.h

#### Functions

esp_err_t **es8388_init**(*audio_hal_codec_config_t *cfg*)
Initialize ES8388 codec chip.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `cfg`: configuration of ES8388

esp_err_t **es8388_deinit**(void)
Deinitialize ES8388 codec chip.

**Return**

- ESP_OK
- ESP_FAIL

esp_err_t **es8388_config_fmt**(es_module_t *mod*, es_i2s_fmt_t *cfg*)
Configure ES8388 I2S format.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mod`: set ADC or DAC or both
- `cfg`: ES8388 I2S format

esp_err_t **es8388_i2s_config_clock**(es_i2s_clock_t *cfg*)
Configure I2s clock in MSATER mode.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `cfg`: set bits clock and WS clock

esp_err_t **es8388_set_bits_per_sample** (es_module_t *mode*, es_bits_length_t *bit_per_sample*)
Configure ES8388 data sample bits.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mode`: set ADC or DAC or both
- `bit_per_sample`: bit number of per sample

esp_err_t **es8388_start** (es_module_t *mode*)
Start ES8388 codec chip.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mode`: set ADC or DAC or both

esp_err_t **es8388_stop** (es_module_t *mode*)
Stop ES8388 codec chip.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mode`: set ADC or DAC or both

esp_err_t **es8388_set_voice_volume** (int *volume*)
Set voice volume.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `volume`: voice volume (0~100)

esp_err_t **es8388_get_voice_volume** (int **volume*)
Get voice volume.

**Return**

- ESP_OK

- ESP_FAIL

**Parameters**

- `[out] *volume`: voice volume (0~100)

esp_err_t **es8388_set_voice_mute**(bool *enable*)
Configure ES8388 DAC mute or not. Basically you can use this function to mute the output or unmute.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `enable`: enable(1) or disable(0)

esp_err_t **es8388_get_voice_mute**(void)
Get ES8388 DAC mute status.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

esp_err_t **es8388_set_mic_gain**(es_mic_gain_t *gain*)
Set ES8388 mic gain.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `gain`: db of mic gain

esp_err_t **es8388_config_adc_input**(es_adc_input_t *input*)
Set ES8388 adc input mode.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `input`: adc input mode

esp_err_t **es8388_config_dac_output**(es_dac_output_t *output*)
Set ES8388 dac output mode.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `output`: dac output mode

esp_err_t **es8388_write_reg** (uint8_t *reg_add*, uint8_t *data*)
Write ES8388 register.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `reg_add`: address of register
- `data`: data of register

void **es8388_read_all** ()
Print all ES8388 registers.

**Return**

- void

esp_err_t **es8388_config_i2s** (*audio_hal_codec_mode_t mode*, *audio_hal_codec_i2s_iface_t *iface*)
Configure ES8388 codec mode and I2S interface.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `mode`: codec mode
- `iface`: I2S config

esp_err_t **es8388_ctrl_state** (*audio_hal_codec_mode_t mode*, *audio_hal_ctrl_t ctrl_state*)
Control ES8388 codec chip.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `mode`: codec mode
- `ctrl_state`: start or stop decode or encode progress

esp_err_t **es8388_pa_power** (bool *enable*)
Set ES8388 PA power.

**Return**

- ESP_ERR_INVALID_ARG

- ESP_OK

**Parameters**

- `enable`: true for enable PA power, false for disable PA power

### Macros

**ES8388_ADDR**
0x22:CE=1;0x20:CE=0

**ES8388_CONTROL1**

**ES8388_CONTROL2**

**ES8388_CHIPPOWER**

**ES8388_ADCPOWER**

**ES8388_DACPOWER**

**ES8388_CHIPLOPOW1**

**ES8388_CHIPLOPOW2**

**ES8388_ANAVOLMANAG**

**ES8388_MASTERMODE**

**ES8388_ADCCONTROL1**

**ES8388_ADCCONTROL2**

**ES8388_ADCCONTROL3**

**ES8388_ADCCONTROL4**

**ES8388_ADCCONTROL5**

**ES8388_ADCCONTROL6**

**ES8388_ADCCONTROL7**

**ES8388_ADCCONTROL8**

**ES8388_ADCCONTROL9**

**ES8388_ADCCONTROL10**

**ES8388_ADCCONTROL11**

**ES8388_ADCCONTROL12**

**ES8388_ADCCONTROL13**

**ES8388_ADCCONTROL14**

**ES8388_DACCONTROL1**

**ES8388_DACCONTROL2**

**ES8388_DACCONTROL3**

**ES8388_DACCONTROL4**

**ES8388_DACCONTROL5**

**ES8388_DACCONTROL6**

**ES8388_DACCONTROL7**

**ES8388_DACCONTROL8**

**ES8388_DACCONTROL9**

**ES8388_DACCONTROL10**

**ES8388_DACCONTROL11**

**ES8388_DACCONTROL12**

**ES8388_DACCONTROL13**

**ES8388_DACCONTROL14**

**ES8388_DACCONTROL15**

**ES8388_DACCONTROL16**

**ES8388_DACCONTROL17**

**ES8388_DACCONTROL18**

**ES8388_DACCONTROL19**

**ES8388_DACCONTROL20**

**ES8388_DACCONTROL21**

**ES8388_DACCONTROL22**

**ES8388_DACCONTROL23**

**ES8388_DACCONTROL24**

**ES8388_DACCONTROL25**

**ES8388_DACCONTROL26**

**ES8388_DACCONTROL27**

**ES8388_DACCONTROL28**

**ES8388_DACCONTROL29**

**ES8388_DACCONTROL30**

### 2.9.4 ES8374 Driver

Driver for ES8374 codec chip.

#### API Reference

#### Header File

- audio_hal/driver/es8374/es8374.h

### Functions

esp_err_t **es8374_codec_init** (*audio_hal_codec_config_t *cfg*)

Initialize ES8374 codec chip.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `cfg`: configuration of ES8374

esp_err_t **es8374_codec_deinit** (void)

Deinitialize ES8374 codec chip.

**Return**

- ESP_OK
- ESP_FAIL

esp_err_t **es8374_config_fmt** (es_module_t *mode*, es_i2s_fmt_t *fmt*)

Configure ES8374 I2S format.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mode`: set ADC or DAC or both
- `fmt`: ES8374 I2S format

esp_err_t **es8374_i2s_config_clock** (es_i2s_clock_t *cfg*)

Configure I2S clock in MSATER mode.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `cfg`: set bits clock and WS clock

esp_err_t **es8374_set_bits_per_sample** (es_module_t *mode*, es_bits_length_t *bit_per_sample*)

Configure ES8374 data sample bits.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mode`: set ADC or DAC or both
- `bit_per_sample`: bit number of per sample

esp_err_t **es8374_start** (es_module_t *mode*)
Start ES8374 codec chip.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mode`: set ADC or DAC or both

esp_err_t **es8374_stop** (es_module_t *mode*)
Stop ES8374 codec chip.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mode`: set ADC or DAC or both

esp_err_t **es8374_codec_set_voice_volume** (int *volume*)
Set voice volume.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `volume`: voice volume (0~100)

esp_err_t **es8374_codec_get_voice_volume** (int **volume*)
Get voice volume.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[out] *volume`: voice volume (0~100)

esp_err_t **es8374_set_voice_mute** (bool *enable*)
Mute or unmute ES8374 DAC. Basically you can use this function to mute or unmute the output.

**Return**

- ESP_FAIL Parameter error

- ESP_OK Success

**Parameters**

- `enable`: mute(1) or unmute(0)

esp_err_t **es8374_get_voice_mute** (void)
Get ES8374 DAC mute status.

**Return**

- ESP_FAIL
- ESP_OK

esp_err_t **es8374_set_mic_gain** (es_mic_gain_t *gain*)
Set ES8374 mic gain.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `gain`: db of mic gain

esp_err_t **es8374_config_adc_input** (es_adc_input_t *input*)
Set ES8374 ADC input mode.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `input`: adc input mode

esp_err_t **es8374_config_dac_output** (es_dac_output_t *output*)
Set ES8374 DAC output mode.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `output`: dac output mode

esp_err_t **es8374_write_reg** (uint8_t *reg_add*, uint8_t *data*)
Write ES8374 register.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `reg_add`: address of register
- `data`: data of register

void **es8374_read_all**()

Print all ES8374 registers.

**Return**

- void

esp_err_t **es8374_codec_config_i2s**(*audio_hal_codec_mode_t mode*, *audio_hal_codec_i2s_iface_t *iface*)

Configure ES8374 codec mode and I2S interface.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `mode`: codec mode
- `iface`: I2S config

esp_err_t **es8374_codec_ctrl_state**(*audio_hal_codec_mode_t mode*, *audio_hal_ctrl_t ctrl_state*)

Control ES8374 codec chip.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `mode`: codec mode
- `ctrl_state`: start or stop decode or encode progress

esp_err_t **es8374_pa_power**(bool *enable*)

Set ES8374 PA power.

**Return**

- ESP_ERR_INVALID_ARG
- ESP_OK

**Parameters**

- `enable`: true for enable PA power, false for disable PA power

### Macros

**ES8374_ADDR**

## 2.9.5 ZL38063 Driver

Driver for ZL38063 codec chip used in *ESP32-LyraTD-MSC* audio board.

### API Reference

### Header File

- audio_hal/driver/zl38063/zl38063.h

### Functions

esp_err_t **zl38063_codec_init**(*audio_hal_codec_config_t *cfg*)

Initialize ZL38063 chip.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `cfg`: configuration of ZL38063

esp_err_t **zl38063_codec_deinit**(void)

Deinitialize ZL38063 chip.

**Return**

- ESP_OK
- ESP_FAIL

esp_err_t **zl38063_codec_ctrl_state**(*audio_hal_codec_mode_t mode*, *audio_hal_ctrl_t ctrl_state*)

Control ZL38063 chip.

The functions zl38063_ctrl_state and zl38063_config_i2s are not used by this driver. They are kept here to maintain the uniformity and convenience of the interface of the ADF project. These settings for zl38063 are burned in firmware and configuration files. Default i2s configuration: 48000Hz, 16bit, Left-Right channels. Use resampling to be compatible with different file types.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `mode`: codec mode
- `ctrl_state`: start or stop decode or encode progress

esp_err_t **zl38063_codec_config_i2s**(*audio_hal_codec_mode_t mode*, *audio_hal_codec_i2s_iface_t *iface*)

Configure ZL38063 codec mode and I2S interface.

**Return**

- ESP_FAIL Parameter error
- ESP_OK Success

**Parameters**

- `mode`: codec mode
- `iface`: I2S config

esp_err_t **zl38063_codec_set_voice_mute**(bool *mute*)

mute or unmute the codec

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `mute`: true, false

esp_err_t **zl38063_codec_set_voice_volume**(int *volume*)

Set voice volume.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `volume`: voice volume (0~100)

esp_err_t **zl38063_codec_get_voice_volume**(int **volume*)

Get voice volume.

**Return**

- ESP_OK
- ESP_FAIL

**Parameters**

- `[out] *volume`: voice volume (0~100)

## 2.10 Configuration Options

Compile-time configuration options specific to ESP-ADF.

### 2.10.1 Audio Codec Device Configuration

#### CODEC_I2C_BACKWARD_COMPATIBLE

Enable backward compatibility for the I2C driver (force use of the old i2c_driver above v5.3)

*Found in: Component config > Audio Codec Device Configuration*

Enable this option for backward compatibility with the old I2C driver

#### CODEC_ES8311_SUPPORT

Support ES8311 Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec ES8311.

#### CODEC_ES7210_SUPPORT

Support ES7210 Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec ES7210.

#### CODEC_ES7243_SUPPORT

Support ES7243 Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec ES7243.

#### CODEC_ES7243E_SUPPORT

Support ES7243E Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec ES7243E.

### CODEC_ES8156_SUPPORT

Support ES8156 Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec ES8156.

### CODEC_AW88298_SUPPORT

Support AW88298 Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec AW88298.

### CODEC_ES8374_SUPPORT

Support ES8374 Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec ES8374.

### CODEC_ES8388_SUPPORT

Support ES8388 Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec ES8388.

### CODEC_TAS5805M_SUPPORT

Support TAS5805M Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec TAS5805M.

### CODEC_ZL38063_SUPPORT

Support ZL38063 Codec Chip

*Found in: Component config > Audio Codec Device Configuration*

Enable this option to support codec ZL38063. ZL38063 firmware only support xtensa, don't enable for RISC-V IC.

## 2.10.2 Audio HAL

### AUDIO_BOARD

Audio board

*Found in: Audio HAL*

Select an audio board to use with the ESP-ADF

**Available options:**

- AUDIO_BOARD_CUSTOM
- ESP_LYRAT_V4_3_BOARD
- ESP_LYRAT_V4_2_BOARD
- ESP_LYRATD_MSC_V2_1_BOARD
- ESP_LYRATD_MSC_V2_2_BOARD
- ESP_LYRAT_MINI_V1_1_BOARD
- ESP32_KORVO_DU1906_BOARD
- ESP32_S2_KALUGA_1_V1_2_BOARD
- ESP32_S3_KORVO2_V3_BOARD
- ESP32_S3_KORVO2L_V1_BOARD
- ESP32_S3_BOX_LITE_BOARD
- ESP32_S3_BOX_BOARD
- ESP32_S3_BOX_3_BOARD
- ESP32_C3_LYRA_V2_BOARD
- ESP32_C6_DEVKIT_BOARD
- ESP32_P4_FUNCTION_EV_BOARD

### ESP32_KORVO_DU1906_DAC

ESP32 KORVO DU1906 Board DAC chip

*Found in: Audio HAL*

Select DAC chip to use on ESP32_KORVO_DU1906 board

**Available options:**

- ESP32_KORVO_DU1906_DAC_TAS5805M
- ESP32_KORVO_DU1906_DAC_ES7148

#### ESP32_KORVO_DU1906_ADC

ESP32 KORVO DU1906 Board ADC chip

*Found in: Audio HAL*

Select ADC chip to use on ESP32_KORVO_DU1906 board

**Available options:**

- ESP32_KORVO_DU1906_ADC_ES7243

### 2.10.3 ADF Features

#### ESP_DISPATCHER_DELEGATE_TASK_CORE

Delegation task core

*Found in: ADF Features*

Pinned delegate task to core 0 or core 1.

#### ESP_DISPATCHER_DELEGATE_TASK_PRIO

Delegate task's prio

*Found in: ADF Features*

The delegate task's prio.

#### ESP_DISPATCHER_DELEGATE_STACK_SIZE

Delegate task's stack size

*Found in: ADF Features*

The delegate task's stack is located in DRAM, modify this size to make sure all the needed operation can be run success in the it.

### 2.10.4 DuerOS Service

#### DUEROS_GEN_PROFILE

Generate the nvs partition which include the profile of dueros

*Found in: Component config > DuerOS Service*

#### DUEROS_FLASH_PROFILE

Flash the generated nvs partition

*Found in: Component config > DuerOS Service*

#### DUEROS_DEVICE_NAME

Duer device name

*Found in: Component config > DuerOS Service*

### 2.10.5 ADF Library Configuration

#### MEDIA_PROTOCOL_LIB_ENABLE

Enable Media Protocol Library

*Found in: ADF Library Configuration*

#### MEDIA_LIB_MEM_AUTO_TRACE

Support trace memory automatically after media_lib_sal init

*Found in: ADF Library Configuration*

#### MEDIA_LIB_MEM_TRACE_DEPTH

Memory trace stack depth

*Found in: ADF Library Configuration*

Set memory trace depth

#### MEDIA_LIB_MEM_TRACE_NUM

Memory trace number

*Found in: ADF Library Configuration*

Set memory trace number

#### MEDIA_LIB_MEM_TRACE_MODULE

Trace for module memory usage

*Found in: ADF Library Configuration*

### MEDIA_LIB_MEM_TRACE_LEAKAGE

Trace for memory leakage

*Found in: ADF Library Configuration*

### MEDIA_LIB_MEM_TRACE_SAVE_HISTORY

Trace to save memory history

*Found in: ADF Library Configuration*

### MEDIA_LIB_MEM_SAVE_CACHE_SIZE

Cache buffer size to store save history

*Found in: ADF Library Configuration*

Set cache size for memory history

### MEDIA_LIB_MEM_TRACE_SAVE_PATH

Memory trace save path

*Found in: ADF Library Configuration*

Set memory trace save path

CHAPTER

THREE

# DESIGN GUIDE

The ESP32 is a powerful chip well positioned as a MCU of the audio projects. This section is intended to provide guidance on process of designing an audio project with the ESP32 inside.

## 3.1 Project Design

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When designing a project with ability to process audio signals or audio data we typically consider a subset of the following components:

**Input:**

- **Analog signal input** to connect e.g. a microphone
- **Storage media**, e.g. microSD card with audio files to read
- **Wi-Fi interface** to obtain an audio data stream from the internet
- **Bluetooth interface** to obtain an audio data stream from e.g. a Bluetooth headset
- **I2S interface** to obtain audio data stream from a codec chip
- **Ethernet interface** to obtain an audio data stream from the internet
- An internal **chip's flash memory** with some audio samples to play
- **User Interface** e.g. buttons or some other means to provide user input

**Output:**

- **Analog signal output** to connect headphones or speakers
- **Storage media**, e.g. microSD card to write some audio files, e.g. with recording
- **Wi-Fi interface** to send out an audio data stream to the internet
- **Bluetooth interface** to stream audio data to e.g. a Bluetooth headset
- **I2S interface** to stream some data to a codec chip
- **Ethernet interface** to stream an audio data stream to the internet
- An internal **chip's flash memory** to store some audio recording
- **User Interface** e.g. a display, LEDs or some means of haptic feedback

**Main Processing Unit:**

A microcontroller or a computer with processing power to read the data from the input, process (e.g. encode / encode) and send to the output.

### 3.1.1 Project Options

The ESP chips (including ESP32, ESP32-S2, ESP32-S3) have all the above features or are able to support them (e.g. can drive Ethernet PHY). Considering the ESP chip cost is low, and availability of ESP-ADF software development platform, we are able to develop an audio project with minimum additional components at very low price.

Depending on the application, required functionality and performance, we may consider two project groups.

- **Minimum** - having minimum additional components, assuming using on board I2S, or PDM interface as well as DAC, if no high qualify audio on the output is required.
- **Typical** - with an external codec chip and a power amplifier, for high quality output audio and multiple input / output options.

There may be several variation between the above projects, by adding or removing features/components. Below are a couple of examples.

### 3.1.2 Project Minimum

With several peripherals on an ESP chip, I2S or PDM or DAC interfaces can be used to implement a minimum project. With the digital microphones, we could input voice signals and build a command voice control project minimum that could communicate with a cloud service.

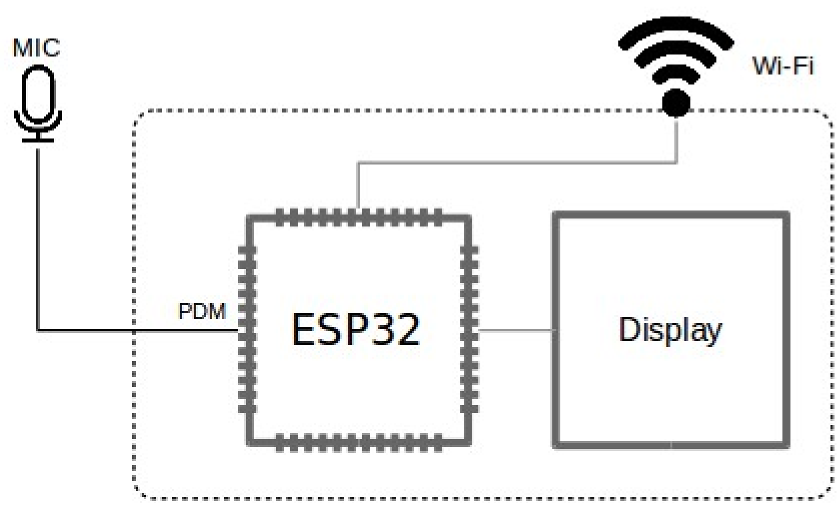



Fig. 1: Audio Project Example - Send Voice Commands to Cloud Service

With two on board DACs, if 8-bit width on the output is satisfactory, we may implement another project minimum - a device to play an internet connected radio.

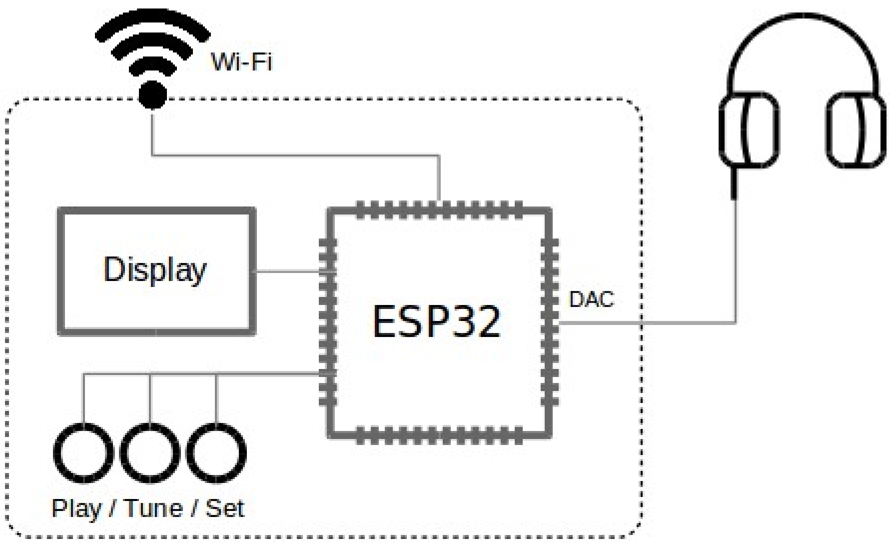



Fig. 2: Audio Project Example - Internet Connected Radio Player

### 3.1.3 Typical Project

When looking for better audio quality and more interfacing options we would use an external I2S codec to do all the analog input and output signal processing. The codec chip, depending on type, may provide additional functionality like audio input signal preamplifier, headphone output amplifier, multiple analog input and outputs, sound effects, etc. The I2S is considered as the industry standard for interfacing with audio codec chips, or in general for a high speed, continuous transfer of the audio data. To optimize performance of audio data processing, an additional memory may be required. For such cases, please consider using ESP32-WROVER-E that provides 8 MB PSRAM on a single module together with the ESP32 chip.

The ESP-ADF is designed primarily to support projects with a codec chip. The *ESP32 LyraT* board is an example of such a project. The software interfacing with the board is done by Audio HAL and a driver. The codec chip used on the ESP32 LyraT is ES8388. Boards with a different codec chip may be supported by providing a different driver.

## 3.2 Design Considerations

Depending on the audio data format, that may be lossless, lossy or compressed, e.g. WAV, MP3 or FLAC and the quality expressed in sampling rate and bitrate, the project will require different resources: memory, storage space, input / output throughput and the processing power. The resources will also depend on the project type and features discussed in *Project Design*.

This section describes capacity and performance of ESP32 system resources that should be considered when designing an audio project to meet required data format, audio quality and functionality.

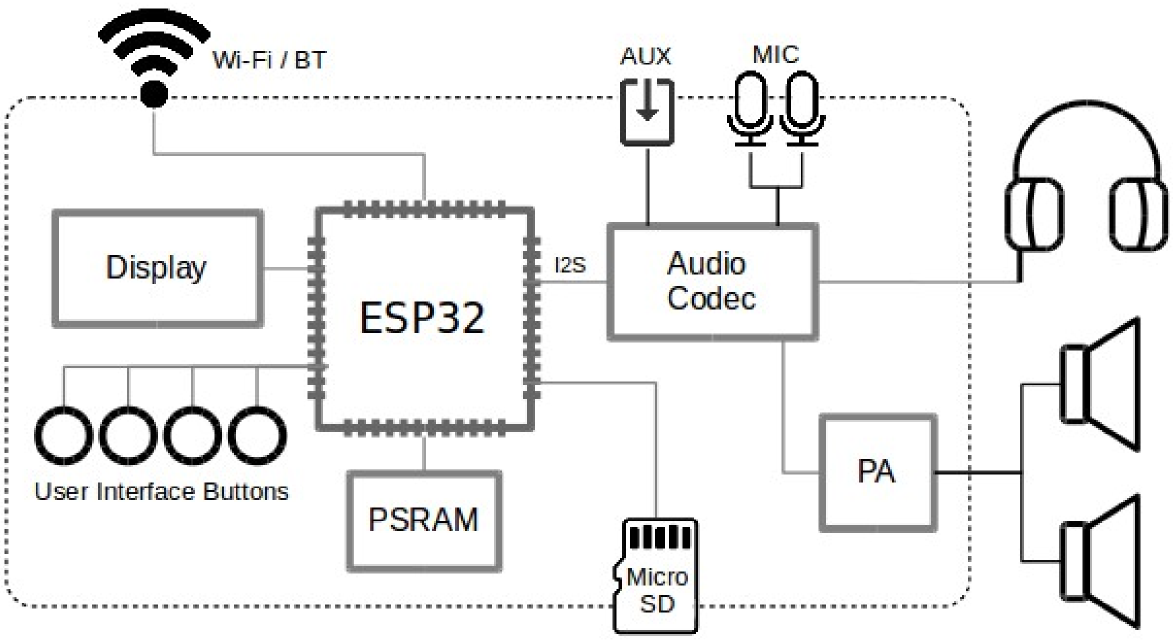



Fig. 3: Typical Audio Project Example

### 3.2.1 Memory

The spare internal Data-RAM is about 290kB with "hello_world" example. For audio system this may be insufficient, and therefore the ESP32 incorporates the ability to use up to 4MB of external SPI RAM (i.e. PSRAM) memory. The external memory is incorporated in the memory map and is, within certain restrictions, usable in the same way internal Data-RAM is.

Refer to External SPI-connected RAM section in IDF documenation for details, especially pay attention to its Restrictions section which is very important.

To be able to use the PSRAM, if installed on your board, it should be enabled in menucofig under *Component config > ESP32-specific > SPI RAM config*. The option *CONFIG_SPIRAM_CACHE_WORKAROUND*, set by default in the same menu, should be kept enabled.

**Note:** Bluetooth and Wi-Fi can not coexist without PSRAM because it will not leave enough memory for an audio application.

### Optimization of Internal RAM and Use of PSRAM

Internal RAM is more valuable asset since there are some restrictions on PSRAM. Here are some tips for optimizing internal RAM.

- If PSRAM is in use, set all the static buffer to minimum value in *Component config > Wi-Fi*; if PSRAM is not used then dynamic buffer should be selected to save memory. Refer to Wi-Fi Buffer Usage section in IDF documentation for details.
- If PSRAM and BT are used, then *CONFIG_BT_ALLOCATION_FROM_SPIRAM_FIRST* and *CONFIG_BT_BLE_DYNAMIC_ENV_MEMORY* should be set as "yes" under *Component config > Bluetooth > Bluedroid Enable*, to allocate more of 40kB memory to PSRAM
- If PSRAM and Wi-Fi are used, then *CONFIG_WIFI_LWIP_ALLOCATION_FROM_SPIRAM_FIRST* should be set as "yes" under *Component config > ESP32-specific > SPI RAM config*, to allocate some memory to PSRAM
- Set *CONFIG_WL_SECTOR_SIZE* as 512 in *Component config > Wear Levelling*

**Note:** The smaller the size of sector be, the slower the Write / Read speed will be, and vice versa, but only 512 and 4096 are supported.

- Call `char *buf = heap_caps_malloc(1024 * 10, MALLOC_CAP_SPIRAM | MALLOC_CAP_8BIT)` instead of `malloc(1024 * 10)` to use PSRAM, and call `char *buf = heap_caps_malloc(512, MALLOC_CAP_INTERNAL | MALLOC_CAP_8BIT)` to use internal RAM.
- Not relying on `malloc()` to automatically allocate PSRAM allows to make a full control of the memory. By avoiding the use of the internal RAM by other `malloc()` calls, you can reserve more memory for high-efficiency usage and task stack since PSRAM cannot be used as task stack memory.
- The task stack will always be allocated at internal RAM. On the other hand you can use of the `xTaskCreateStatic()` function that allows to create tasks with stack on PSRAM (see options in PSRAM and FreeRTOS menuconfig), but pay attention to its help information.

**Important:** Don't use ROM code in `xTaskCreateStatic` task The ROM code itself is linked in `components/esp32/ld/esp32.rom.ld`. However, you also need to consider other pieces of code that *call* ROM functions, as well as the code that is not recompiled against the *CONFIG_SPIRAM_CACHE_WORKAROUND* patch, like the Wi-Fi and Bluetooth libraries. In general, we advise using this only in threads that do not call any IDF libraries (including libc), doing only calculations and using FreeRTOS primitives to talk to other threads.

### Memory Usage by Component Overview

Below is a table that contains ESP-ADF components and their memory usage. Choose the components needed and find out how much internal RAM is left. The table is divided into two parts, when PSRAM is used or not. If PSRAM (external RAM) is in use, then some of the memory will be allocated at PSRAM automatically.

The initial spare internal RAM is 290kB.

| Component | Internal RAM Required | |
|---|---|---|
| | PSRAM not used | With PSRAM |
| Wi-Fi [1] | 50kB+ | 50kB+ |
| Bluetooth | 140kB (50kB if only BLE needed) | 95kB (50kB if only BLE needed) |
| Flash Card [2] | 12kB+ | 12kB+ |
| I2S [3] | Configurable, 8kB for reference | Configurable, 8kB for reference |
| RingBuffer [4] | Configurable, 30kB for reference | 0kB, all moved into PSRAM |

**Notes to the table above**

1. According to the Wi-Fi menuconfig each Tx and Rx buffer occupies 1.6kB internal RAM. The value of 50kB RAM is assuming use of 5 Rx static buffers and 6 Tx static buffers. If PSRAM is not in use, then the "Type of WiFi Tx Buffer" option should be set as *DYNAMIC* in order to save RAM, in this case, the RAM usage will be far less than 50kB, but programmer should keep at least 50kB available for the Wi-Fi to be able to transmit the data. **[Internal RAM only]**
2. Taking ESP32-LyraT V4.3 as an example, depending on value of *SDCARD_OPEN_FILE_NUM_MAX* in audio_board/lyrat_v4_3/board_def.h, that is then used in `sdcard_mount()` function, the RAM needed will increase with a greater number of maximum open files. 12kB is the RAM needed with 5 max files and 512 bytes *CONFIG_WL_SECTOR_SIZE*. **[Internal RAM only]**
3. Depending on configuration settings of the I2S stream, refer to audio_stream/include/i2s_stream.h and audio_stream/i2s_stream.c. **[Internal RAM only]**
4. Depending on configuration setting of the Ringbuffer, refer to *DEFAULT_PIPELINE_RINGBUF_SIZE* in audio_pipeline/include/audio_pipeline.h or user setting, if the buffer is created with e.g. `rb_create()`.

## 3.2.2 System Settings

The following settings are recommended to achieve a high Wi-Fi performance in an audio project.

**Note:** Use ESP32 modules and boards from reputable vendors that put attention to product design, component selection and product testing. This is to have confidence of receiving well designed boards with calibrated RF.

- Set these following options in menuconfig.
  - Flash SPI mode as QIO
  - Flash SPI speed as 80MHz
  - CPU frequency as 240MHz
  - Set *Default receive window size* as 5 times greater than *Maximum Segment Size* in *Component config > LWIP > TCP*
- If external antenna is used, then set *PHY_RF_CAL_PARTIAL* as *PHY_RF_CAL_FULL* in ''esp-idf/components/esp32/phy_init.c"

## 3.3 Software Design

Espressif audio framework project.

### 3.3.1 Features

1. All of Streams and Codecs based on audio element.
2. All events based on queue.
3. Audio pipeline supports dynamic combination.
4. Audio pipeline supports multiple elements.
5. Pipeline Support functionality plug-in.
6. Audio common peripherals support work in the one task.
7. Support post-event mechanism in peripherals.
8. Support high level audio play API based on element and audio pipeline.
9. Audio high level interface supports dynamic adding of codec library.
10. Audio high level interface supports dynamic adding of input and output stream.
11. ESP audio supports multiple audio pipelines.

### 3.3.2 Design Components

Five basic components are - Audio Element, Audio Event, Audio Pipeline, ESP peripherals, ESP audio

#### Audio Element

#### Example

Please refer to audio_stream/fatfs_stream.c for an example of using an audio element.

#### Audio Event

#### Example

Please refer to player/pipeline_http_mp3/main/play_http_mp3_example.c for an example of using an audio event.

#### Audio Pipeline

#### Example

Please refer to player/pipeline_play_sdcard_music/main/play_sdcard_music_example.c for an example of linking elements into an audio pipeline.

### Audio Peripheral

#### Example

```
ESP_LOGI(TAG, "[ 3 ] Start and wait for Wi-Fi network");
esp_periph_config_t periph_cfg = DEFAULT_ESP_PERIPH_SET_CONFIG();
esp_periph_set_handle_t set = esp_periph_set_init(&periph_cfg);
periph_wifi_cfg_t wifi_cfg = {
    .wifi_config.sta.ssid = CONFIG_WIFI_SSID,
    .wifi_config.sta.password = CONFIG_WIFI_PASSWORD,
};
esp_periph_handle_t wifi_handle = periph_wifi_init(&wifi_cfg);
esp_periph_start(set, wifi_handle);
periph_wifi_wait_for_connected(wifi_handle, portMAX_DELAY);
```

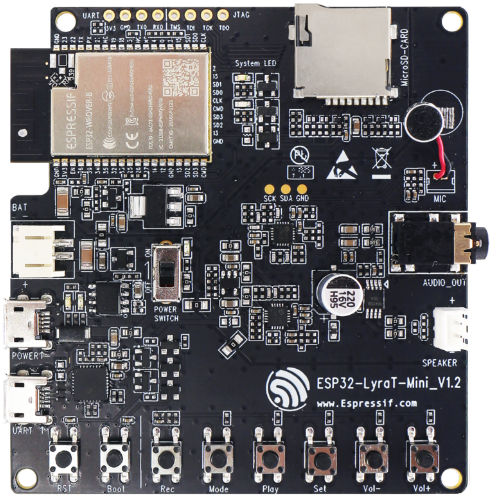
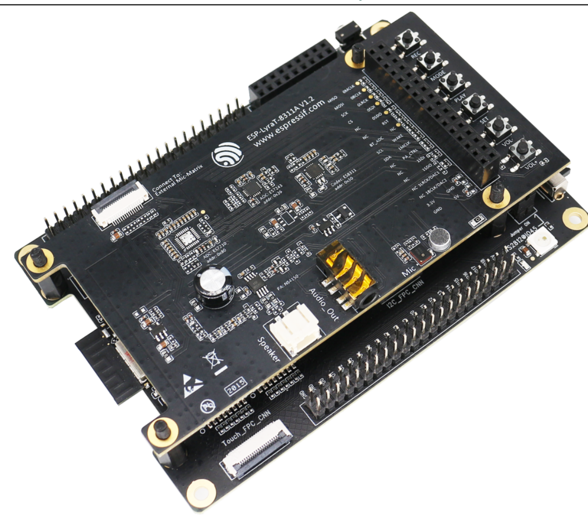
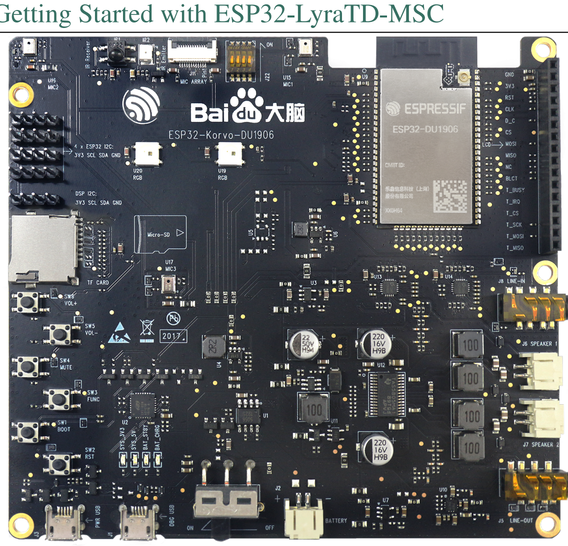
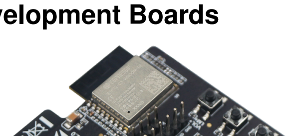
### Audio Player

#### Example

Please refer to cli for an example of initializing `esp_audio` as an audio player.

## 3.4 Development Boards

Below are getting started guides and hardware details of audio development boards designed by Espressif.

| | |
|---|---|
|  |  |
| Getting Started with ESP32-LyraT | Getting Started with ESP32-LyraT-Mini |
| Hardware Reference of ESP32-LyraT | Hardware Reference of ESP32-LyraT-Mini |
|  |  |
| Getting Started with ESP32-LyraTD-MSC | Getting Started with ESP32-S2-Kaluga-1-Kit |
|  |  |
| Getting Started with ESP32-Korvo-DU1906 | Getting Started with ESP32-S3-Korvo-2 |
|  | |

### 3.4.1 ESP32-LyraT-Mini V1.2 Getting Started Guide

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This guide provides users with functional descriptions, configuration options for ESP32-LyraT-Mini V1.2 audio development board, as well as how to get started with the ESP32-LyraT board.

The ESP32-LyraT is a hardware platform designed for the dual-core ESP32 audio applications, e.g., Wi-Fi or BT audio speakers, speech-based remote controllers, connected smart-home appliances with one or more audio functionality, etc.

The ESP32-LyraT-Mini is a mono audio board. If you are looking for a stereo audio board, check *ESP32-LyraT V4.3 Getting Started Guide*.

#### What You Need

- *ESP32-LyraT-Mini V1.2 board*
- Speaker or headphones with a 3.5 mm jack. If you use a speaker, it is recommended to choose one no more than 3 watts, and JST PH 2.0 2-Pin plugs are needed. In case you do not have this type of plug it is also fine to use Dupont female jumper wires during development.
- Two Micro-USB 2.0 cables, Type A to Micro B
- PC loaded with Windows, Linux or Mac OS

Optional components

- Micro SD-card
- Li-ion Battery

If you like to start using this board right now, go directly to section *Start Application Development*.

#### Overview

The ESP32-LyraT-Mini V1.2 is an audio development board produced by Espressif built around ESP32. It is intended for audio applications, by providing hardware for audio processing and additional RAM on top of what is already on-board of the ESP32 chip. The specific hardware includes:

- **ESP32-WROVER-E module**
- **Audio codec chip**
- **ADC chip**
- **Microphone** on board
- **Audio output**
- **1 x 3-watt speaker** output
- **MicroSD card** slot (1 line)
- **Eight keys**
- **Two system LEDs**
- **JTAG** and **UART** test points
- Integrated **USB-UART Bridge Chip**
- Li-ion **Battery-Charge Management**

The block diagram below presents main components of the ESP32-LyraT-Mini and interconnections between components.

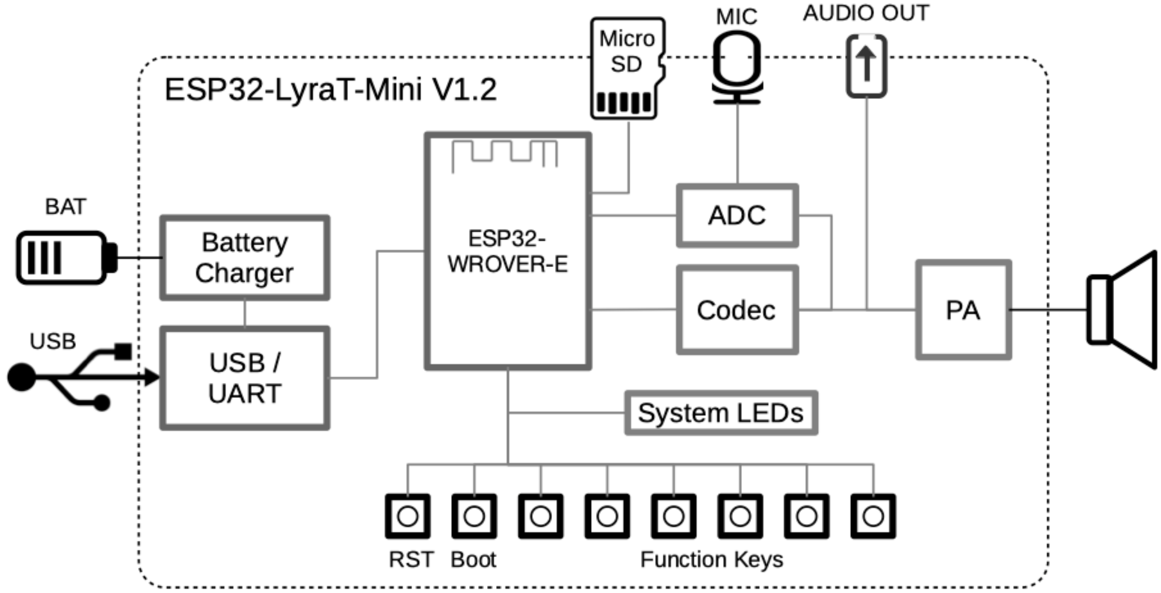


Fig. 4: ESP32-LyraT-Mini Block Diagram

## Components

The following list and figure describe key components, interfaces and controls of the ESP32-LyraT-Mini used in this guide. For detailed technical documentation of this board, please refer to *ESP32-LyraT-Mini V1.2 Hardware Reference* and ESP32-LyraT-Mini V1.2 schematic (PDF). The list below provides description starting from the picture's top right corner and going clockwise.

**Audio Codec Chip** The audio codec chip, ES8311, is a low power mono audio codec. It consists of 1-channel ADC, 1-channel DAC, low noise pre-amplifier, headphone driver, digital sound effects, analog mixing and gain functions. It is interfaced with **ESP32-WROVER-E Module** over I2S and I2C buses to provide audio processing in hardware independently from the audio application.

**Audio Output** Output socket to connect headphones with a 3.5 mm stereo jack. (Please note that the board outputs a mono signal)

**Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**USB-UART Port** Functions as the communication interface between a PC and the ESP32.

**USB Power Port** Provides the power supply for the board.

**Standby / Charging LEDs** The **Standby** green LED indicates that power has been applied to the **USB Power Port**. The **Charging** red LED indicates that a battery connected to the **Battery Socket** is being charged.

**Power On Switch** Power on/off knob: toggling it to the top powers the board on; toggling it to the down powers the board off.

**Power On LED** Red LED indicating that **Power On Switch** is turned on.

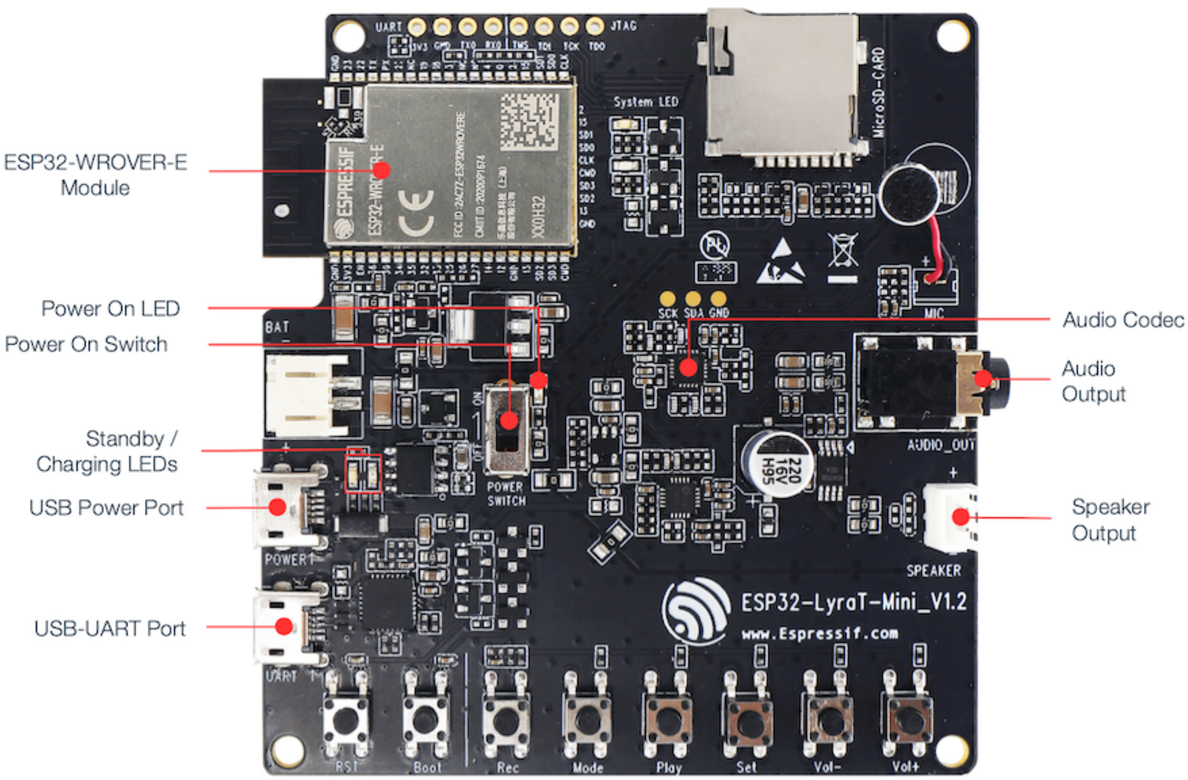


Fig. 5: ESP32 LyraT-Mini V1.2 Board Layout Overview

**ESP32-WROVER-E Module** The ESP32-WROVER-E module contains ESP32 chip to provide Wi-Fi / Bluetooth connectivity and data processing power as well as integrates 4 MB external SPI flash and an additional 8 MB PSRAM for flexible data storage.

### Start Application Development

Before powering up the ESP32-LyraT-Mini, please make sure that the board has been received in good condition with no obvious signs of damage.

#### Initial Setup

Prepare the board for loading of the first sample application:

1. Connect speaker to the **Speaker Output**. Connecting headphones to the **Audio Output** is an option.
2. Plug in the Micro-USB cables to the PC and to **both USB ports** of the ESP32-LyraT-Mini.
3. The **Standby LED** (green) should turn on. Assuming that a battery is not connected, the **Charging LED** (red) will blink every couple of seconds.
4. Toggle top the **Power On Switch**.
5. The red **Power On LED** should turn on.

If this is what you see on the LEDs, the board should be ready for application upload. Now prepare the PC by loading and configuring development tools what is discussed in the next section.

#### Develop Applications

Once the board is initially set up and checked, you can start preparing the development tools. The Section *Installation Step by Step* will walk you through the following steps:

- **Set up ESP-IDF** to get a common development framework for the ESP32 (and ESP32-S2) chips in C language;
- **Get ESP-ADF** to install the API specific to audio applications;
- **Set up env** to make the framework aware of the audio specific API;
- **Start a Project** that will provide a sample audio application for the board;
- **Connect Your Device** to prepare the application for loading;
- **Build the Project** to finally run the application and play some music.

### Revision History

- Changed the integrated module to ESP32-WROVER-E from ESP32-WROVER-B.

### Other Boards from LyraT Family

- *ESP32-LyraT V4.3 Getting Started Guide*
- *ESP32-LyraTD-MSC V2.2 Getting Started Guide*

### Related Documents

- ESP32-LyraT-Mini V1.2 schematic (PDF)
- ESP32-LyraT-Mini V1.2 Board Dimensions (PDF)
- *ESP32-LyraT-Mini V1.2 Hardware Reference*
- ESP32 Datasheet (PDF)
- ESP32-WROVER-E Datasheet (PDF)

## 3.4.2 ESP32-LyraT-Mini V1.2 Hardware Reference

This guide provides functional descriptions and configuration options for ESP32-LyraT-Mini V1.2 audio development board. As an introduction to functionality and using the LyraT, please see *ESP32-LyraT-Mini V1.2 Getting Started Guide*.

**In this Section**

### Overview

ESP32-LyraT is a hardware platform designed for the dual-core ESP32 audio applications, e.g., Wi-Fi or BT audio speakers, speech-based remote controllers, connected smart-home appliances with one or more audio functionality, etc.

The block diagram below presents main components of ESP32-LyraT-Mini.

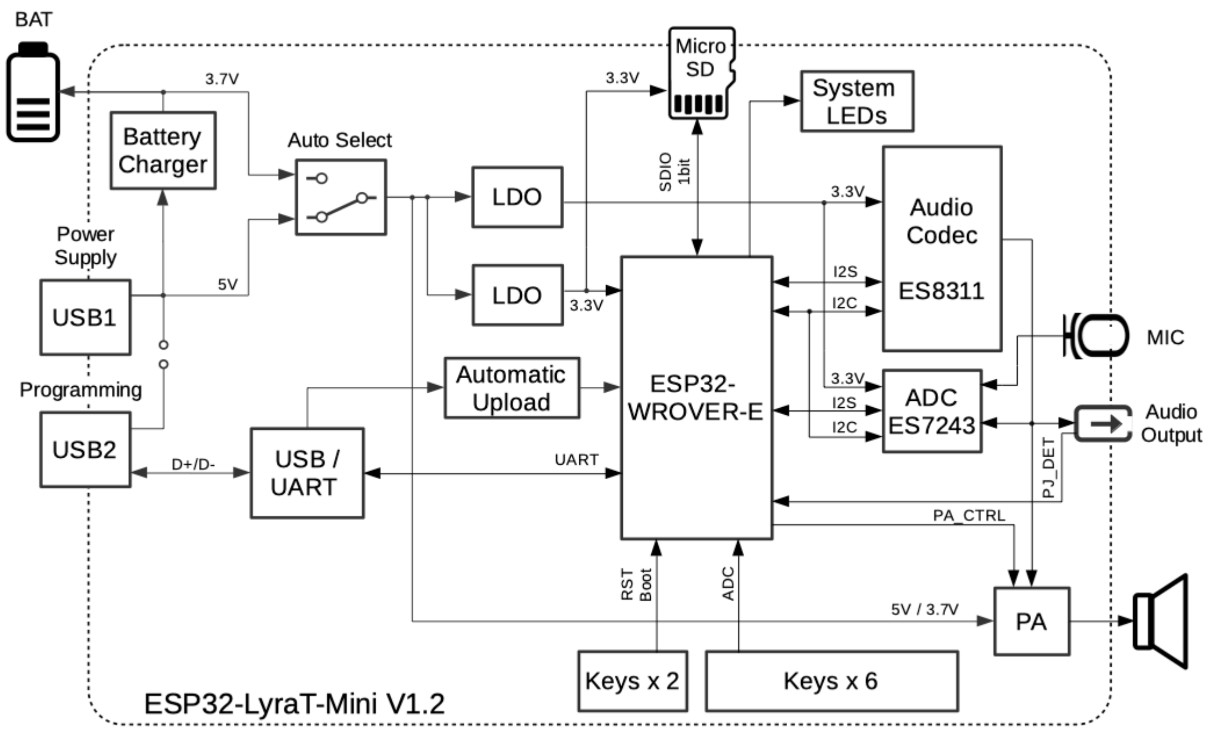


Fig. 6: ESP32-LyraT-Mini V1.2 Electrical Block Diagram

### Functional Description

The following list and figure describe key components, interfaces, and controls of the ESP32-LyraT-Mini board. The list provides description starting from the picture's top right corner and going clockwise.

**MicroSD Slot** The development board supports a MicroSD card in SPI/1-bit modes, and can store or play audio files in the MicroSD card. See *MicroSD Card* for pinout details.

**Microphone** On-board microphone connected to AINRP/AINRP of the **Audio ADC Chip**.

**System LEDs** Two general purpose LEDs (green and red) controlled by **ESP32-WROVER-E Module** to indicate certain operation states of the audio application using dedicated API.

**Audio Codec** The audio codec chip, ES8311, is a low power mono audio codec. It consists of 1-channel ADC, 1-channel DAC, low noise pre-amplifier, headphone driver, digital sound effects, analog mixing, and gain functions. It is interfaced with **ESP32-WROVER-E Module** over I2S and I2C buses to provide audio processing in hardware independently from the audio application.

**Audio Output** Output socket to connect headphones with a 3.5 mm stereo jack. One of the socket's terminals is wired to ESP32 to provide jack insertion detection.

**ADC** The audio codec chip, ES7243, is a low power multi-bit delta-sigma audio ADC and DAC. In this board this chip is used as the microphone interface.

**PA** A power amplifier used to amplify the audio signal from the **Audio Codec Chip** for driving the speaker.

**Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**Function Press Keys** Six press keys labeled **Rec**, **Mode**, **Play**, **Set**, **Vol-**, and **Vol+**. They are routed to **ESP32-WROVER-E Module** and intended for development and testing of a UI for audio applications using dedicated API.

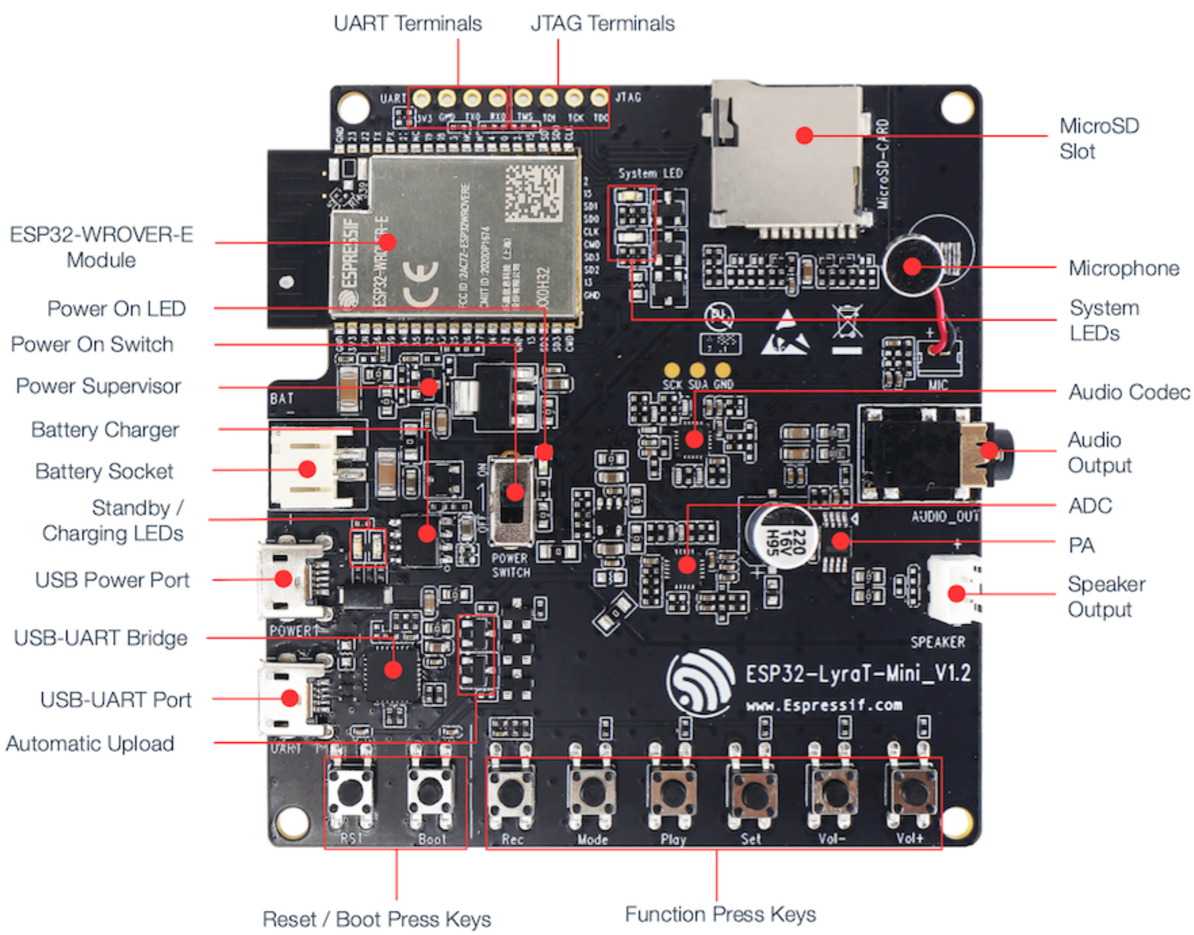


Fig. 7: ESP32 LyraT-Mini V1.2 Board Layout

**Boot/Reset Press Keys** Boot: holding down the **Boot** button and momentarily pressing the **Reset** button initiates the firmware upload mode. Then user can upload firmware through the serial port. Reset: pressing this button alone resets the system.

**Automatic Upload** A simple two transistor circuit to put ESP32 into firmware upload mode depending on the status of UART DTR and RTS signals. The signals are controlled by an external application to upload the firmware over the USB-UART interface.

**USB-UART Port** Functions as the communication interface between a PC and the ESP32 module.

**USB-UART Bridge** A single chip USB-UART bridge CP2102N provides up to 3 Mbps transfers rates.

**USB Power Port** Provides the power supply for the board.

**Standby/Charging LEDs** The **Standby** green LED indicates that power has been applied to the **USB Power Port**. The **Charging** red LED indicates that a battery connected to the **Battery Socket** is being charged.

**Battery Socket** Two-pin socket to connect a single cell Li-ion battery. The pins have a 2.00 mm / 0.08” pitch. The battery serves as an alternative power supply to the **USB Power Port** for charging the board. Make sure to use a Li-ion battery that has protection circuit and fuse. The recommended specifications of the battery: capacity > 1000 mAh, output voltage 3.7 V, input voltage 4.2 V – 5 V. Please verify if polarity on the battery plug matches polarity of the socket as marked on the board’s soldermask besides the socket.

**Battery Charger** Constant current and constant voltage linear charger for single cell lithium-ion batteries AP5056. Used for charging of a battery connected to the **Battery Socket** over the **USB Power Port**.

**Power Supervisor** Provides EN signal to enable ESP32 once power supply voltage stabilizes.

**Power On Switch** Power on/off knob: toggling it to the top powers the board on; toggling it to the down powers the board off.

> **Note:** The **Power On Switch** does not affect / disconnect the Li-ion battery charging. More information, you can refer to ESP32-LyraT-Mini V1.2 schematic (PDF).

**Power On LED** Red LED indicating that **Power On Switch** is turned on.

**ESP32-WROVER-E Module** The ESP32-WROVER-E module contains ESP32 chip to provide Wi-Fi / Bluetooth connectivity and data processing power as well as integrates 4 MB external SPI flash and an additional 8 MB PSRAM for flexible data storage.

**UART Termininals** Serial port: provides access to the serial TX/RX signals between **ESP32-WROVER-E Module** and **USB-UART Bridge Chip**. See *UART Test Point* for pinout details.

**JTAG Termininals** Provides access to the **JTAG** interface of **ESP32-WROVER-E Module**. It may be used for debugging, application upload, as well as implementing several other functions, e.g., Application Level Tracing. See *JTAG Test Point* for pinout details.

### Allocation of ESP32 Pins to Test Points

This section describes allocation of test points available on the ESP32-LyraT-Mini board.

The test points are bare through hole solder pads and have standard 2.54 mm / 0.1 inch pitch. User may need to populate them with pin headers or sockets for easy connection of external hardware.

#### JTAG Test Point

| . | ESP32 Pin | JTAG Signal |
|---|---|---|
| 1 | MTDO / GPIO15 | TDO |
| 2 | MTCK / GPIO13 | TCK |
| 3 | MTDI / GPIO12 | TDI |
| 4 | MTMS / GPIO14 | TMS |

### UART Test Point

| . | ESP32 Pin | Pin Description |
|---|---|---|
| 1 | RXD0 | RX |
| 2 | TXD0 | TX |
| 3 | GND | GND |
| 4 | n/a | 3.3 V |

### MicroSD Card

Implemented on this board MicoSD card interface operates in SPI/1-bit mode. The board is able to support SPI/4-bit mode after populating couple of additional components on locations reserved on the PCB. See ESP32-LyraT-Mini V1.2 schematic (PDF) for additional information. Not populated components are marked *(NC)* on the schematic.

| . | ESP32 Pin | MicroSD Signal |
|---|---|---|
| 1 | MTDI / GPIO12 | – |
| 2 | MTCK / GPIO13 | – |
| 3 | MTDO / GPIO15 | CMD |
| 4 | MTMS / GPIO14 | CLK |
| 5 | GPIO2 | DATA0 |
| 6 | GPIO4 | – |
| 7 | GPIO34 | CD |

### GPIO Allocation Summary

The table below provides allocation of GPIOs exposed on terminals of **ESP32-WROVER-E Module** to control specific components or functions of the board.

| Pin [1] | Pin Name | ES8311 | ES7243 | Keys | MicroSD | Other |
|---|---|---|---|---|---|---|
| 3 | EN | | | EN_KEY | | |
| 4 | S_VP | | I2S_DATA | | | |
| 5 | S_VN | | | REC, MODE, PLAY, SET, VOL-, VOL+ | | |
| 6 | IO34 | | | | CD | |
| 7 | IO35 | I2S0_ASDOUT | | | | |
| 8 | IO32 | | I2S1_SCLK | | | |
| 9 | IO33 | | I2S1_LRCK | | | |
| 10 | IO25 | I2S0_LRCK | | | | |
| 11 | IO26 | I2S0_DSDIN | | | | |
| 12 | IO27 | | | | | Blue_LED |
| 13 | IO14 | | | | CLK | |
| 14 | IO12 | | | | NC (DATA2) | |
| 16 | IO13 | | | | NC (DATA3) | |
| 17 | SD2 | | | | | |
| 18 | SD3 | | | | | |
| 19 | CMD | | | | | |
| 20 | CLK | | | | | |
| 21 | SD0 | | | | | |
| 22 | SD1 | | | | | |

Continued on next page

Table 1 – continued from previous page

| Pin [1] | Pin Name | ES8311 | ES7243 | Keys | MicroSD | Other |
|---|---|---|---|---|---|---|
| 23 | IO15 | | | | CMD | |
| 24 | IO2 | | | IO2_KEY | DATA0 | |
| 25 | IO0 | I2S0_MCLK | I2S1_MCLK | IO0_KEY | | |
| 26 | IO4 | | | | NC (DATA1) | |
| 27 | NC (IO16) | | | | | |
| 28 | NC (IO17) | | | | | |
| 29 | IO5 | I2S0_SCLK | | | | |
| 30 | IO18 | I2C_SDA | I2C_SDA | | | |
| 31 | IO19 | | | | | PJ_DET [2] |
| 33 | IO21 | | | | | PA_CTRL [3] |
| 34 | RXD0 | | | | | RXD0 [4] |
| 35 | TXD0 | | | | | TXD0 [4] |
| 36 | IO22 | | | | | Green_LED |
| 37 | IO23 | I2C_SCK | I2C_SCL | | | |

1. **Pin** - ESP32-WROVER-E module pin number, GND and power supply pins are not listed
2. **PJ_DET** - phone jack insertion detect signal
3. **PA_CTRL** - NS4150 power amplifier chip control signal
4. **RXD0**, **TXD0** - serial communication signals connected to TXD and RXD pins of CP2102N USB-UART bridge
5. **NC** - not connected

### Notes on Power Distribution

The ESP32-LyraT-Mini board provides some basic features to isolate noise from digital components by providing separate power distribution for audio and digital subsystems.

#### Power Supply over USB and from Battery

There are two ways to power the development board: 5 V USB Power Port or 3.7 V optional battery. The optional battery is preferable for applications where a cleaner power supply is required.

#### Independent Audio and Digital Power Supply

The board features independent power supplies to the audio components and the ESP32 module. This should reduce noise in the audio signal from digital components and improve overall performance of the components.

### Selecting of the Audio Output

The board provides a mono audio output signal on pins OUTN and OUTP of the ES8311 codec chip. The signal is routed to two outputs:

- Power amplifier (PA) to drive an external speaker
- Phone jack socket to drive external headphones

The board design assumes that selection between one of these outputs is implemented in software, as opposed to using traditional mechanical contacts in a phone jack socket, that would disconnect the speaker once a headphone jack is inserted.

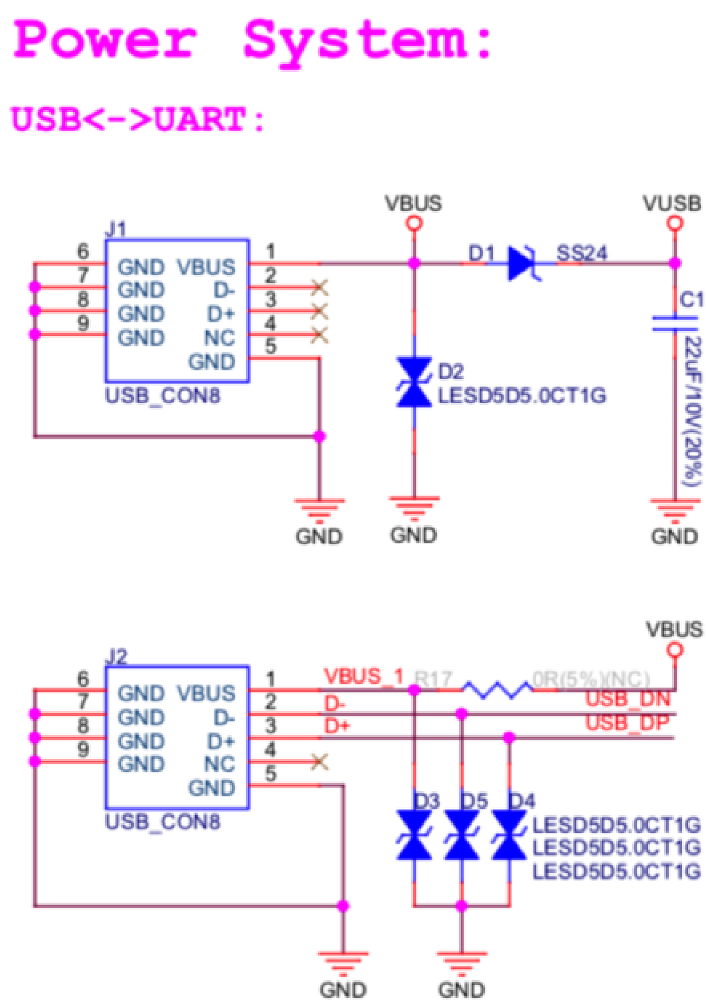


Fig. 8: ESP32-LyraT-Mini V1.2 - Dedicated USB Power Supply Socket

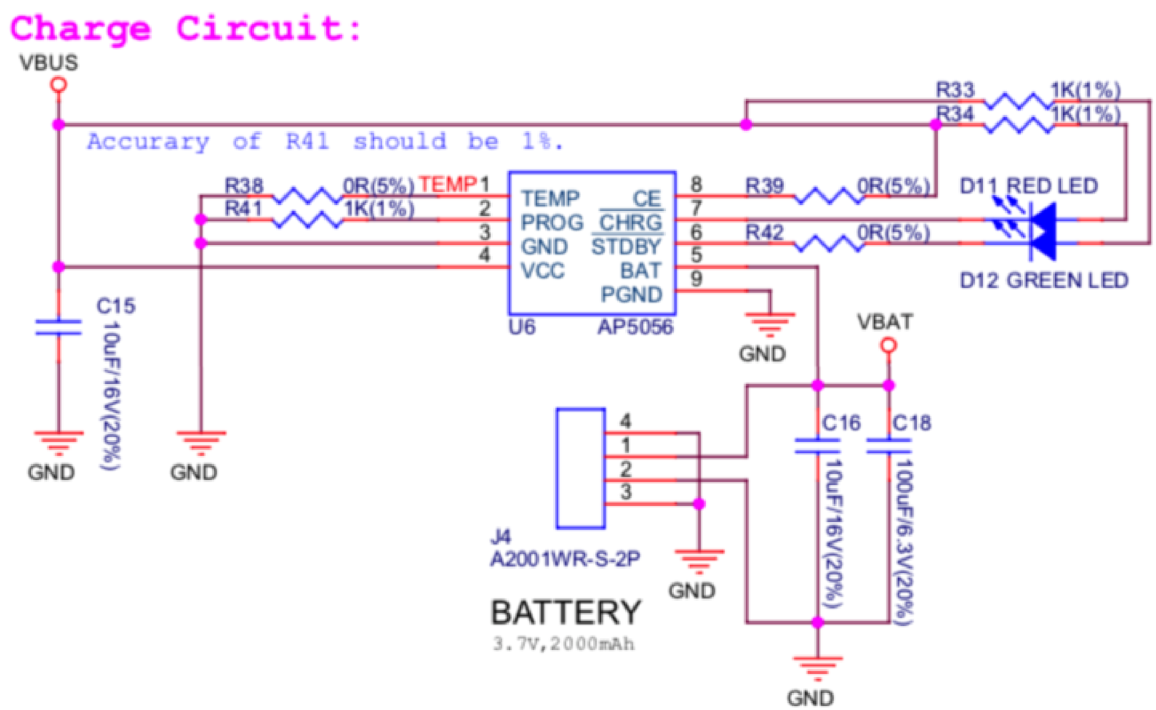


Fig. 9: ESP32-LyraT-Mini V1.2 - Power Supply from a Battery

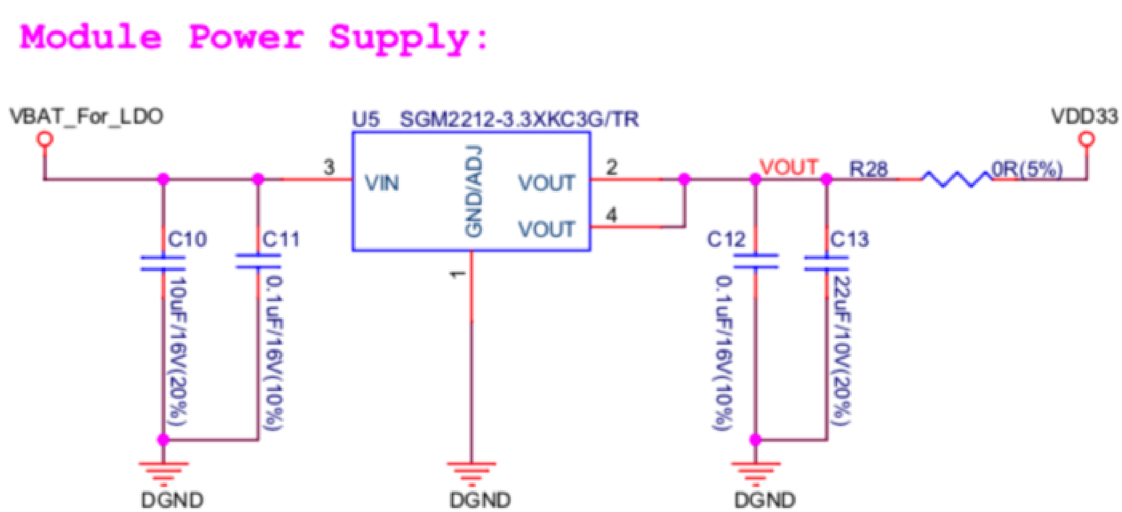


Fig. 10: ESP32-LyraT-Mini V1.2 - Digital Power Supply

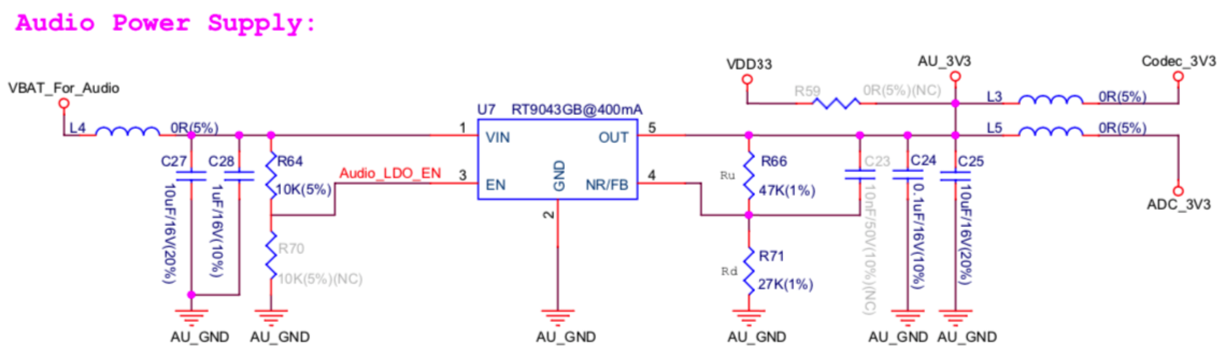


Fig. 11: ESP32-LyraT-Mini V1.2 - Audio Power Supply

Two digital IO signals are provided to implement selection between the speaker and the headphones:

- **PJ_DET** - digital input signal to o detect when a headphone jack is inserted,
- **PA_CTRL** - digital output signal to enable or disable the amplifier IC.

The application running on ESP32 may then enable or disable the PA with **PA_CTRL** basing on status of **PJ_DET**. Please see *GPIO Allocation Summary* for specific GPIO numbers allocated to these signals.

#### Related Documents

- ESP32-LyraT-Mini V1.2 Schematic (PDF)
- ESP32-LyraT-Mini V1.2 Board Dimensions (PDF)
- *ESP32-LyraT-Mini V1.2 Getting Started Guide*
- ESP32 Datasheet (PDF)
- ESP32-WROVER-E Datasheet (PDF)

### 3.4.3 ESP32-LyraT V4.3 Getting Started Guide

[]

This guide provides users with functional descriptions, configuration options for ESP32-LyraT V4.3 audio development board, as well as how to get started with the ESP32-LyraT board. Check section *Other Versions of LyraT*, if you have different version of this board.

The ESP32-LyraT is a hardware platform designed for the dual-core ESP32 audio applications, e.g., Wi-Fi or Bluetooth audio speakers, speech-based remote controllers, connected smart-home appliances with one or more audio functionality, etc.

The ESP32-LyraT is a stereo audio board. If you are looking for a mono audio board, intended for lower end applications, check *ESP32-LyraT-Mini V1.2 Getting Started Guide*.

### What You Need

- 1 × *ESP32 LyraT V4.3 board*
- 2 x Speaker or headphones with a 3.5 mm jack. If you use a speaker, it is recommended to choose one no more than 3 watts, and JST PH 2.0 2-Pin plugs are needed. In case you do not have this type of plug it is also fine to use Dupont female jumper wires during development.
- 2 x Micro-USB 2.0 cables, Type A to Micro B
- 1 × PC loaded with Windows, Linux or Mac OS

If you like to start using this board right now, go directly to section *Start Application Development*.

### Overview

The ESP32-LyraT V4.3 is an audio development board produced by Espressif built around ESP32. It is intended for audio applications, by providing hardware for audio processing and additional RAM on top of what is already onboard of the ESP32 chip. The specific hardware includes:

- ESP32-WROVER-E Module
- Audio Codec Chip
- Dual Microphones on board
- Headphone output
- 2 x 3-watt Speaker output
- Dual Auxiliary Input
- MicroSD Card slot (1 line or 4 lines)
- Six buttons (2 physical buttons and 4 touch buttons)
- JTAG header
- Integrated USB-UART Bridge Chip
- Li-ion Battery-Charge Management

The block diagram below presents main components of the ESP32-LyraT and interconnections between components.

### Components

The following list and figure describe key components, interfaces and controls of the ESP32-LyraT used in this guide. This covers just what is needed now. For detailed technical documentation of this board, please refer to *ESP32-LyraT V4.3 Hardware Reference* and ESP32 LyraT V4.3 schematic (PDF).

**ESP32-WROVER-E Module** The ESP32-WROVER-E module contains ESP32 chip to provide Wi-Fi / Bluetooth connectivity and data processing power as well as integrates 4 MB external SPI flash and an additional 8 MB PSRAM for flexible data storage.

**Headphone Output** Output socket to connect headphones with a 3.5 mm stereo jack.

> **Note:** The socket may be used with mobile phone headsets and is compatible with OMPT standard headsets only. It does not work with CTIA headsets. Please refer to Phone connector (audio) on Wikipedia.

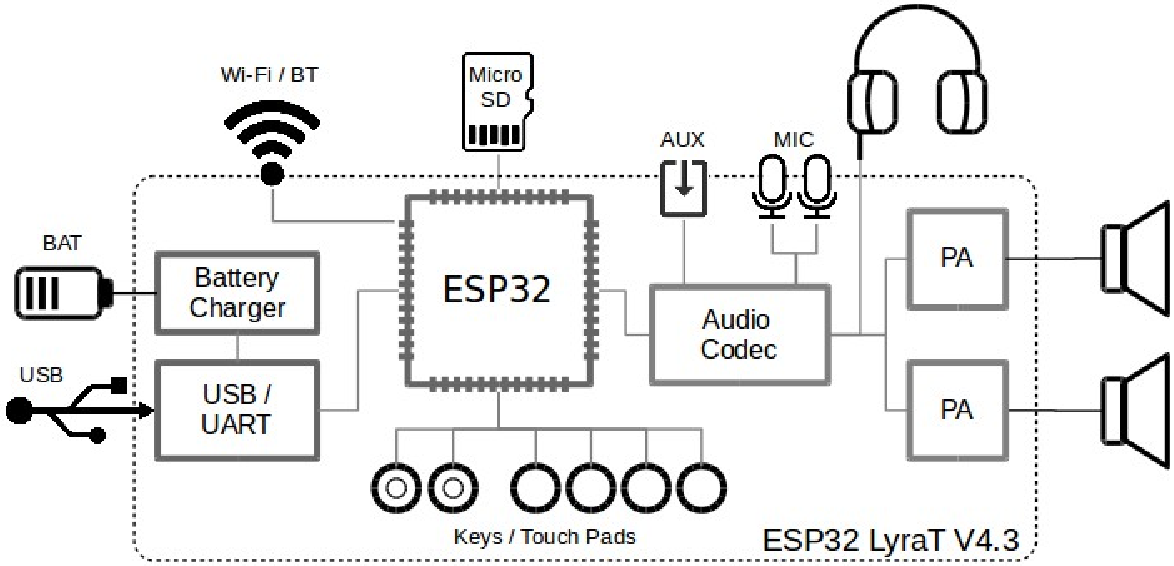


Fig. 12: ESP32-LyraT Block Diagram

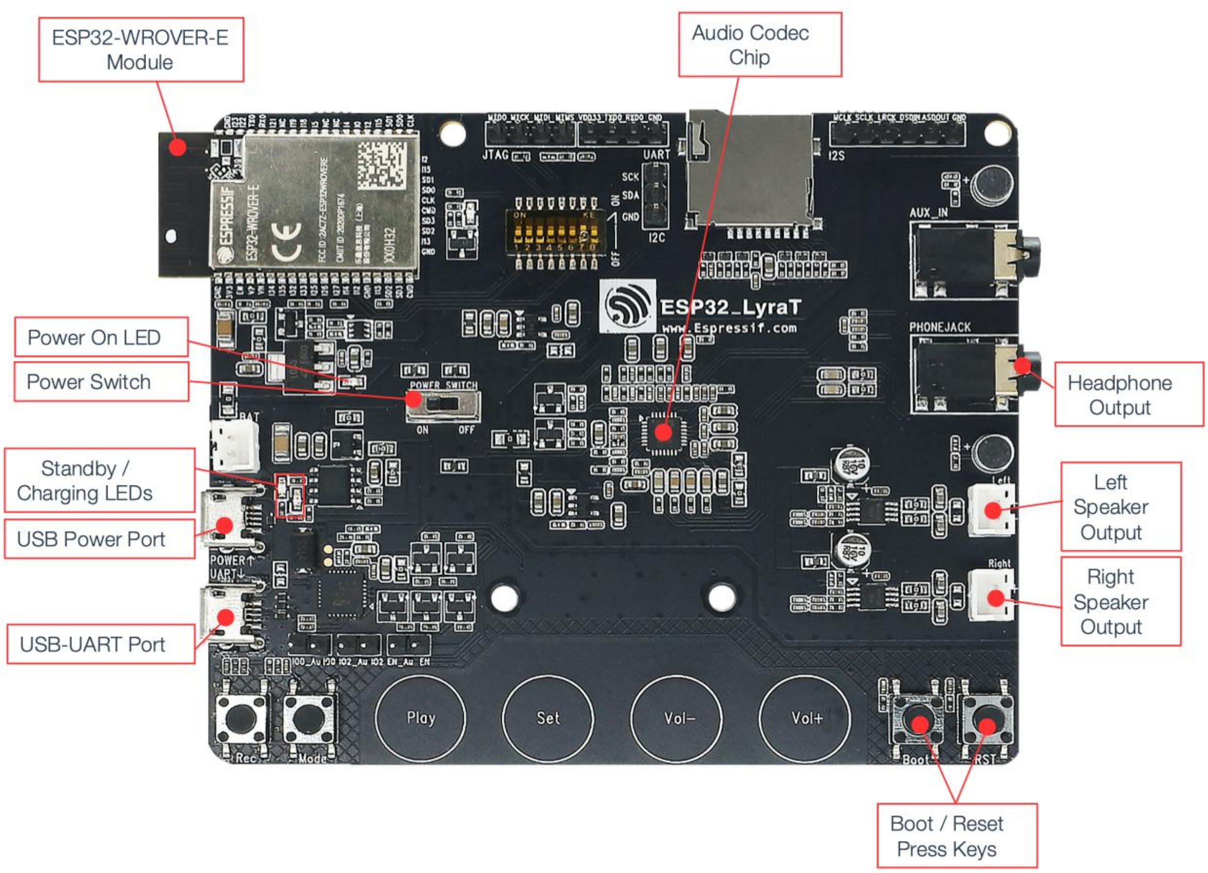


Fig. 13: ESP32-LyraT V4.3 Board Layout Overview

**Left Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**Right Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**Boot/Reset Press Keys** Boot: holding down the **Boot** button and momentarily pressing the **Reset** button initiates the firmware upload mode. Then user can upload firmware through the serial port. Reset: pressing this button alone resets the system.

**Audio Codec Chip** The Audio Codec Chip, ES8388, is a low power stereo audio codec with a headphone amplifier. It consists of 2-channel ADC, 2-channel DAC, microphone amplifier, headphone amplifier, digital sound effects, analog mixing and gain functions. It is interfaced with **ESP32-WROVER-E Module** over I2S and I2S buses to provide audio processing in hardware independently from the audio application.

**USB-UART Port** Functions as the communication interface between a PC and the **ESP32-WROVER-E Module**.

**USB Power Port** Provides the power supply for the board.

**Standby / Charging LEDs** The **Standby** green LED indicates that power has been applied to the **Micro USB Port**. The **Charging** red LED indicates that a battery connected to the **Battery Socket** is being charged.

**Power Switch** Power on/off knob: toggling it to the left powers the board on; toggling it to the right powers the board off.

**Power On LED** Red LED indicating that **Power On Switch** is turned on.

### Start Application Development

Before powering up the ESP32-LyraT, please make sure that the board has been received in good condition with no obvious signs of damage.

### Initial Setup

Prepare the board for loading of the first sample application:

1. Connect speakers to the **Right** and **Left Speaker Output**. Connecting headphones to the **Headphone Output** is an option.
2. Plug in the Micro-USB cables to the PC and to **both USB ports** of the ESP32 LyraT.
3. The **Standby LED** (green) should turn on. Assuming that a battery is not connected, the **Charging LED** (red) will blink every couple of seconds.
4. Toggle left the **Power On Switch**.
5. The red **Power On LED** should turn on.

If this is what you see on the LEDs, the board should be ready for application upload. Now prepare the PC by loading and configuring development tools what is discussed in the next section.

### Develop Applications

Once the board is initially set up and checked, you can start preparing the development tools. The Section *Installation Step by Step* will walk you through the following steps:

- **Set up ESP-IDF** to get a common development framework for the ESP32 (and ESP32-S2) chips in C language;
- **Get ESP-ADF** to install the API specific to audio applications;
- **Set up env** to make the framework aware of the audio specific API;
- **Start a Project** that will provide a sample audio application for the board;
- **Connect Your Device** to prepare the application for loading;
- **Build the Project** to finally run the application and play some music.

### Summary of Key Changes from LyraT V4.2

- Changed the integrated module to ESP32-WROVER-E from ESP32-WROVER.
- Removed Red LED indicator light.
- Introduced headphone jack insert detection.
- Replaced single Power Amplifier (PA) chip with two separate chips.
- Updated power management design of several circuits: Battery Charging, ESP32, MicorSD, Codec Chip and PA.
- Updated electrical implementation design of several circuits: UART, Codec Chip, Left and Right Microphones, AUX Input, Headphone Output, MicroSD, Push Buttons and Automatic Upload.

### Other Versions of LyraT

- *ESP32-LyraT V4.2 Getting Started Guide*
- *ESP32-LyraT V4 Getting Started Guide*

### Other Boards from LyraT Family

- *ESP32-LyraT-Mini V1.2 Getting Started Guide*
- *ESP32-LyraTD-MSC V2.2 Getting Started Guide*

### Related Documents

- *ESP32-LyraT V4.3 Hardware Reference*
- ESP32 LyraT V4.3 schematic (PDF)
- ESP32-LyraT V4.3 Component Layout (PDF)
- ESP32 Datasheet (PDF)
- ESP32-WROVER-E Datasheet (PDF)

### 3.4.4 ESP32-LyraT V4.3 Hardware Reference

This guide provides functional descriptions, configuration options for ESP32-LyraT V4.3 audio development board. As an introduction to functionality and using the LyraT, please see *ESP32-LyraT V4.3 Getting Started Guide*. Check section *Other Versions of LyraT* if you have different version of the board.

**In this Section**



#### Overview

The ESP32-LyraT development board is a hardware platform designed for the dual-core ESP32 audio applications, e.g., Wi-Fi or BT audio speakers, speech-based remote controllers, smart-home appliances with audio functionality(ies), etc.

The block diagram below presents main components of the ESP32-LyraT.

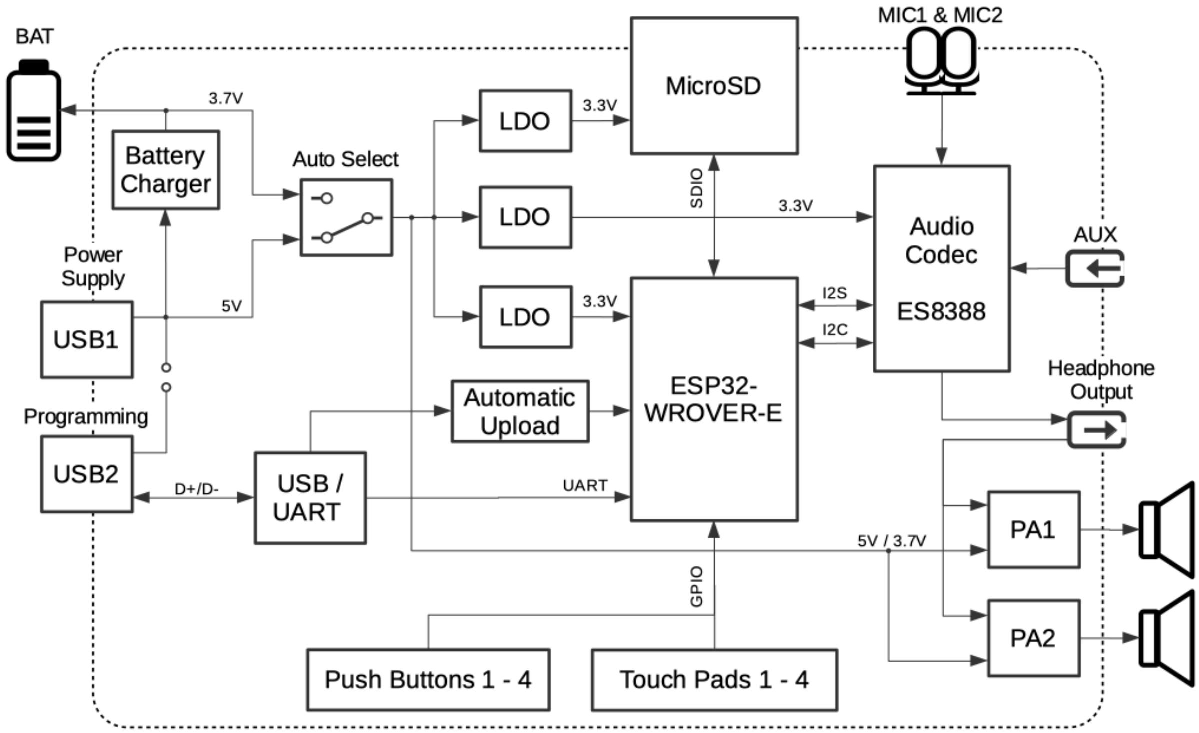


Fig. 14: ESP32-LyraT V4.3 Electrical Block Diagram

### Functional Description

The following list and figure describe key components, interfaces and controls of the ESP32-LyraT board.

**ESP32-WROVER-E Module** The ESP32-WROVER-E module contains ESP32 chip to provide Wi-Fi / Bluetooth connectivity and data processing power as well as integrates 4 MB external SPI flash and an additional 8 MB PSRAM for flexible data storage.

**Green LED** A general purpose LED controlled by the **ESP32-WROVER-E Module** to indicate certain operation states of the audio application using dedicated API.

**Function DIP Switch** Used to configure function of GPIO12 to GPIO15 pins that are shared between devices, primarily between **JTAG Header** and **MicroSD Card**. By default, the **MicroSD Card** is enabled with all switches in *OFF* position. To enable the **JTAG Header** instead, switches in positions 3, 4, 5 and 6 should be put *ON*. If **JTAG** is not used and **MicroSD Card** is operated in the one-line mode, then GPIO12 and GPIO13 may be assigned to other functions. Please refer to ESP32 LyraT V4.3 schematic for more details.

**JTAG Header** Provides access to the **JTAG** interface of **ESP32-WROVER-E Module**. It may be used for debugging, application upload, as well as implementing several other functions, e.g., Application Level Tracing. See *JTAG Header / JP7* for pinout details. Before using **JTAG** signals to the header, **Function DIP Switch** should be enabled. Please note that when **JTAG** is in operation, **MicroSD Card** cannot be used and should be disconnected because some of JTAG signals are shared by both devices.

**UART Header** Serial port: provides access to the serial TX/RX signals between **ESP32-WROVER-E Module** and **USB-UART Bridge Chip**.

**I2C Header** Provides access to the I2C interface. Both **ESP32-WROVER-E Module** and **Audio Codec Chip** are connected to this interface. See *I2C Header / JP5* for pinout details.

**MicroSD Slot** The development board supports a MicroSD card in SPI/1-bit/4-bit modes, and can store or play audio files in the MicroSD card. Note that **JTAG** cannot be used and should be disconnected by setting **Function DIP Switch** when **MicroSD Card** is in operation, because some of signals are shared by both devices.

**I2S Header** Provides access to the I2S interface. Both **ESP32-WROVER-E Module** and **Audio Codec Chip** are connected to this interface. See *I2S Header / JP4* for pinout details.

**Left Microphone** Onboard microphone connected to IN1 of the **Audio Codec Chip**.

**AUX Input** Auxiliary input socket connected to IN2 (left and right channel) of the **Audio Codec Chip**. Use a 3.5 mm stereo jack to connect to this socket.

**Headphone Output** Output socket to connect headphones with a 3.5 mm stereo jack.

**Note:** The socket may be used with mobile phone headsets and is compatible with OMPT standard headsets only. It does work with CTIA headsets. Please refer to Phone connector (audio) on Wikipedia.

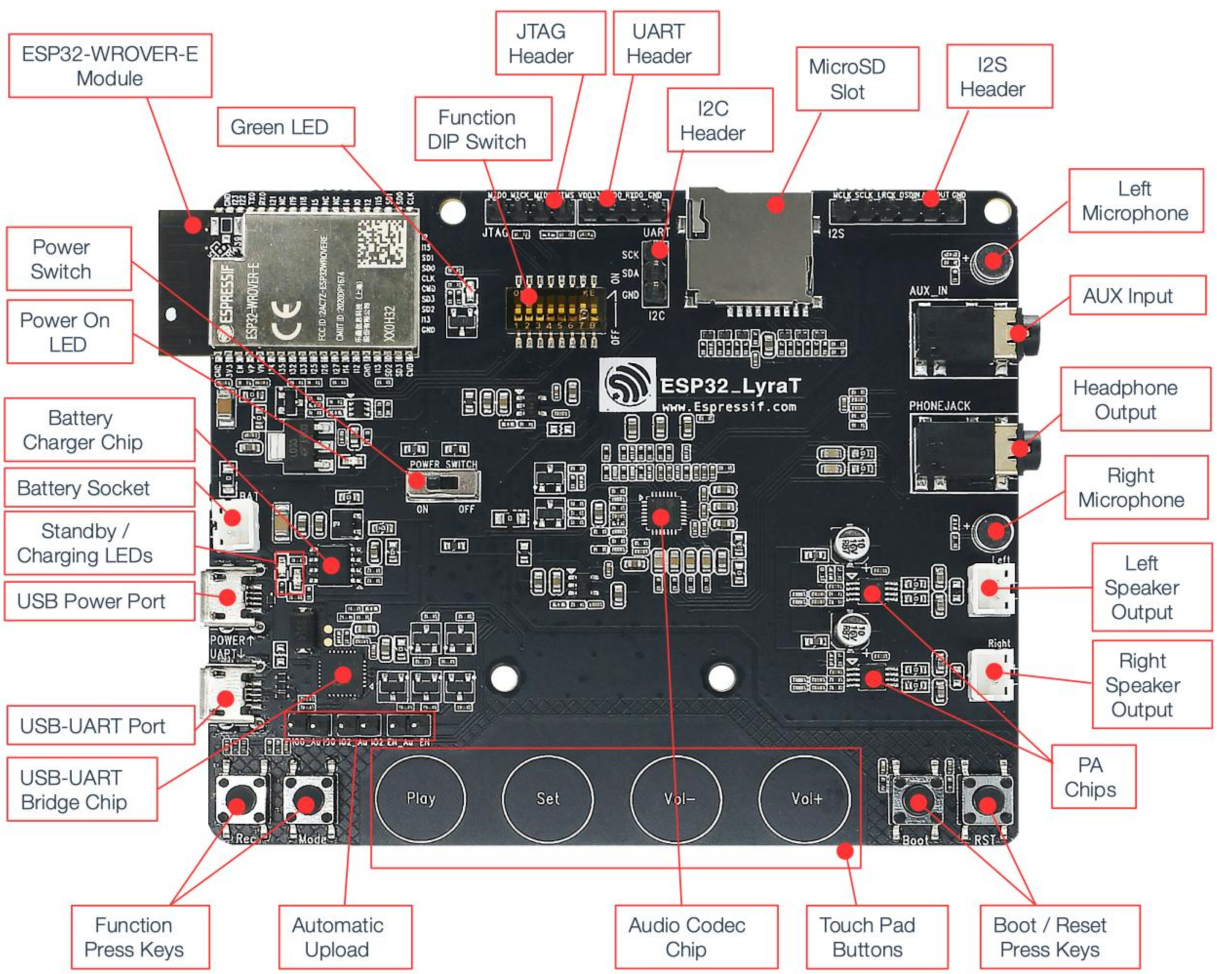


Fig. 15: ESP32-LyraT V4.3 Board Layout

**Right Microphone** Onboard microphone connected to IN1 of the **Audio Codec Chip**.

**Left Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**Right Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**PA Chip** A power amplifier used to amplify stereo audio signal from the **Audio Codec Chip** for driving two speakers.

**Boot/Reset Press Keys** Boot button: holding down the **Boot** button and momentarily pressing the **Reset** button to initiate the firmware download mode. Then you can download firmware through the serial port. Reset button: pressing this button alone resets the system.

**Touch Pad Buttons** Four touch pads labeled *Play*, *Sel*, *Vol+* and *Vol-*. They are routed to **ESP32-WROVER-E Module** and intended for development and testing of a UI for audio applications using dedicated API.

**Audio Codec Chip** The Audio Codec Chip, ES8388, is a low power stereo audio codec with a headphone amplifier. It consists of 2-channel ADC, 2-channel DAC, microphone amplifier, headphone amplifier, digital sound effects, analog mixing and gain functions. It is interfaced with **ESP32-WROVER-E Module** over I2S and I2S buses to provide audio processing in hardware independently from the audio application.

**Automatic Upload** Install three jumpers on this header to enable automatic loading of application to the ESP32. Install all jumpers together on all three headers. Remove all jumpers after upload is complete.

**Function Press Keys** Two key labeled *Rec* and *Mode*. They are routed to **ESP32-WROVER-E Module** and intended for developing and testing a UI for audio applications using dedicated API.

**USB-UART Bridge Chip** A single chip USB-UART bridge provides up to 1 Mbps transfers rate.

**USB-UART Port** Functions as the communication interface between a PC and the ESP32 module.

**USB Power Port** Provides the power supply for the board.

**Standby / Charging LEDs** The **Standby** green LED indicates that power has been applied to the **Micro USB Port**. The **Charging** red LED indicates that a battery connected to the **Battery Socket** is being charged.

**Battery Socket** Two pins socket to connect a single cell Li-ion battery.

**Note:** Please verify if polarity on the battery plug matches polarity of the socket as marked on the board's soldermask besides the socket.

**Battery Charger Chip** Constant current & constant voltage linear charger for single cell lithium-ion batteries AP5056. Used for charging of a battery connected to the **Battery Socket** over the **Micro USB Port**.

**Power On LED** Red LED indicating that **Power On Switch** is turned on.

**Note:** The **Power On Switch** does not affect / disconnect the Li-ion battery charging.

**Power Switch** Power on/off knob: toggling it to the left powers the board on; toggling it to the right powers the board off.

### Hardware Setup Options

There are a couple of options to change the hardware configuration of the ESP32-LyraT board. The options are selectable with the **Function DIP Switch**.

### Enable MicroSD Card in 1-wire Mode

| DIP SW | Position |
|---|---|
| 1 | OFF |
| 2 | OFF |
| 3 | OFF |
| 4 | OFF |
| 5 | OFF |
| 6 | OFF |
| 7 | OFF [1] |
| 8 | n/a |

1. **AUX Input** detection may be enabled by toggling the DIP SW 7 *ON*. Note that the **AUX Input** signal pin should not be be plugged in when the system powers up. Otherwise the ESP32 may not be able to boot correctly.

In this mode:

- **JTAG** functionality is not available
- *Vol-* touch button is available for use with the API

### Enable MicroSD Card in 4-wire Mode

| DIP SW | Position |
|---|---|
| 1 | ON |
| 2 | ON |
| 3 | OFF |
| 4 | OFF |
| 5 | OFF |
| 6 | OFF |
| 7 | OFF |
| 8 | n/a |

In this mode:

- **JTAG** functionality is not available
- *Vol-* touch button is not available for use with the API
- **AUX Input** detection from the API is not available

### Enable JTAG

| DIP SW | Position |
|---|---|
| 1 | OFF |
| 2 | OFF |
| 3 | ON |
| 4 | ON |
| 5 | ON |
| 6 | ON |
| 7 | ON |
| 8 | n/a |

In this mode:

- **MicroSD Card** functionality is not available, remove the card from the slot
- *Vol-* touch button is not available for use with the API
- **AUX Input** detection from the API is not available

### Using Automatic Upload

Entering of the ESP32 into upload mode may be done in two ways:

- Manually by pressing both **Boot** and **RST** keys and then releasing first **RST** and then **Boot** key.
- Automatically by software performing the upload. The software is using **DTR** and **RTS** signals of the serial interface to control states of **EN**, **IO0** and **IO2** pins of the ESP32. This functionality is enabled by installing jumpers in three headers **JP23**, **JP24** and **JP25**. For details see ESP32 LyraT V4.3 schematic. Remove all jumpers after upload is complete.

### Allocation of ESP32 Pins

Several pins ESP32 module are allocated to the on board hardware. Some of them, like GPIO0 or GPIO2, have multiple functions. Please refer to the table below or ESP32 LyraT V4.3 schematic for specific details.

| GPIO Pin | Type | Function Definition |
|---|---|---|
| SENSOR_VP | I | Audio **Rec** (PB) |
| SENSOR_VN | I | Audio **Mode** (PB) |
| IO32 | I/O | Audio **Set** (TP) |
| IO33 | I/O | Audio **Play** (TP) |
| IO27 | I/O | Audio **Vol+** (TP) |
| IO13 | I/O | JTAG **MTCK**, MicroSD **D3**, Audio **Vol-** (TP) |
| IO14 | I/O | JTAG **MTMS**, MicroSD **CLK** |
| IO12 | I/O | JTAG **MTDI**, MicroSD **D2**, Aux signal **detect** |
| IO15 | I/O | JTAG **MTDO**, MicroSD **CMD** |
| IO2 | I/O | Automatic Upload, MicroSD **D0** |
| IO4 | I/O | MicroSD **D1** |
| IO34 | I | MicroSD insert **detect** |
| IO0 | I/O | Automatic Upload, I2S **MCLK** |
| IO5 | I/O | I2S **SCLK** |
| IO25 | I/O | I2S **LRCK** |
| IO26 | I/O | I2S **DSDIN** |
| IO35 | I | I2S **ASDOUT** |
| IO19 | I/O | Headphone jack insert **detect** |
| IO22 | I/O | Green LED indicator |
| IO21 | I/O | PA Enable output |
| IO18 | I/O | I2C **SDA** |
| IO23 | I/O | I2C **SCL** |

- (TP) - touch pad
- (PB) - push button

### Pinout of Extension Headers

There are several pin headers available to connect external components, check the state of particular signal bus or debug operation of ESP32. Note that some signals are shared, see section *Allocation of ESP32 Pins* for details.

#### UART Header / JP2

| | Header Pin |
|---|---|
| 1 | 3.3V |
| 2 | TX |
| 3 | RX |
| 4 | GND |

#### I2S Header / JP4

| | I2C Header Pin | ESP32 Pin |
|---|---|---|
| 1 | MCLK | GPI0 |
| 2 | SCLK | GPIO5 |
| 1 | LRCK | GPIO25 |
| 2 | DSDIN | GPIO26 |
| 3 | ASDOUT | GPIO35 |
| 3 | GND | GND |

#### I2C Header / JP5

| | I2C Header Pin | ESP32 Pin |
|---|---|---|
| 1 | SCL | GPIO23 |
| 2 | SDA | GPIO18 |
| 3 | GND | GND |

#### JTAG Header / JP7

| | ESP32 Pin | JTAG Signal |
|---|---|---|
| 1 | MTDO / GPIO15 | TDO |
| 2 | MTCK / GPIO13 | TCK |
| 3 | MTDI / GPIO12 | TDI |
| 4 | MTMS / GPIO14 | TMS |

### Notes of Power Distribution

The board features quite extensive power distribution system. It provides independent power supplies to all critical components. This should reduce noise in the audio signal from digital components and improve overall performance of the components.

### Power Supply Separation

The main power supply is 5V and provided by a USB. The secondary power supply is 3.7V and provided by an optional battery. The USB power itself is fed with a dedicated cable, separate from a USB cable used for an application upload. To further reduce noise from the USB, the battery may be used instead of the USB.

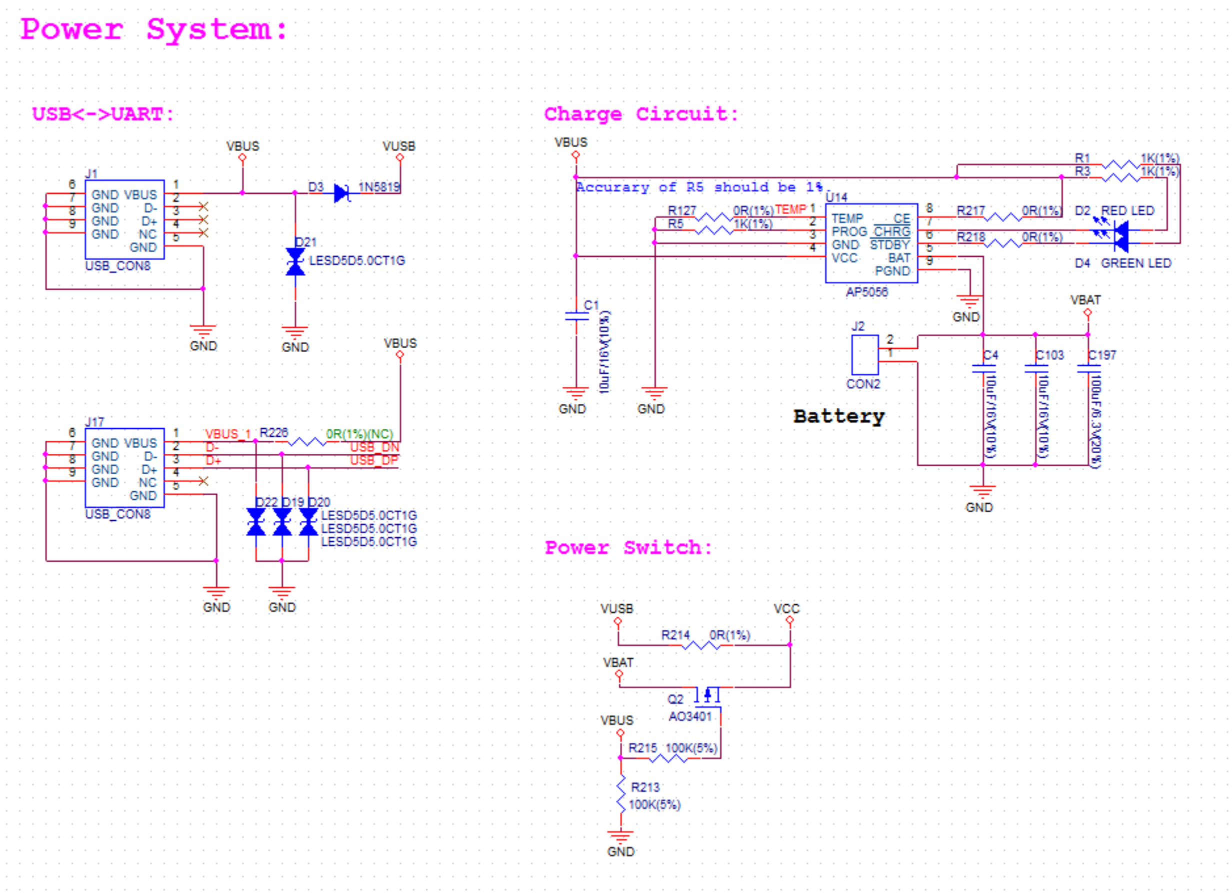


Fig. 16: ESP32 LyraT V4.3 - Power Supply Separation

### Three Dedicated LDOs

**ESP32 Module**

To provide enough current the ESP32, the development board adopts LD1117S33CTR LDO capable to supply the maximum output current of 800mA.

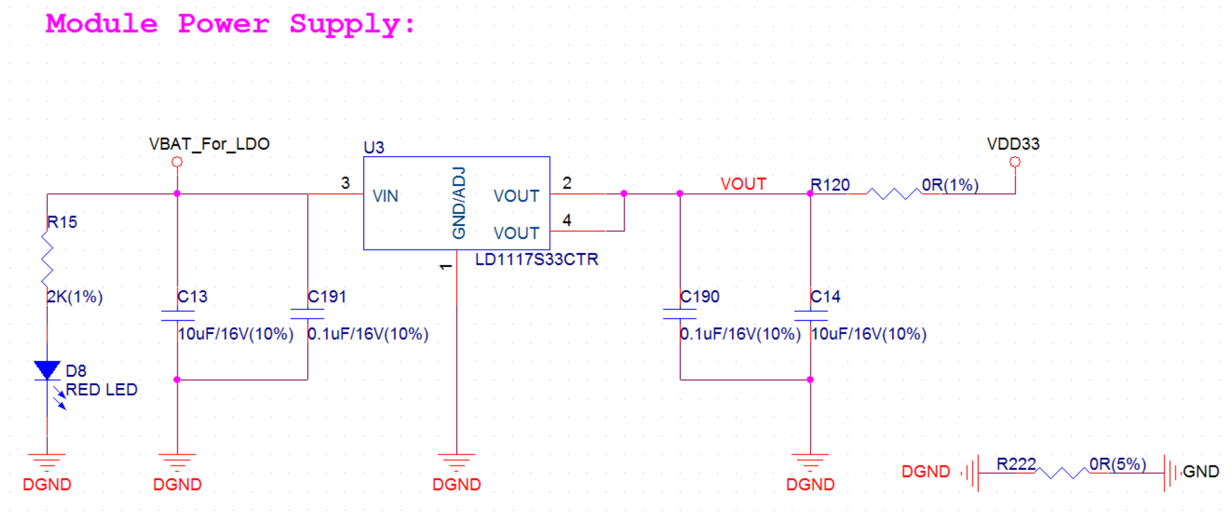


Fig. 17: ESP32 LyraT V4.3 - Dedicated LDO for the ESP32 Module

**MicroSD Card** and **Audio Codec**

Two separate LDOs are provided for the MicorSD Card and the Audio Codec. Both circuits have similar design that includes an inductor and double decoupling capacitors on both the input and output of the LDO.

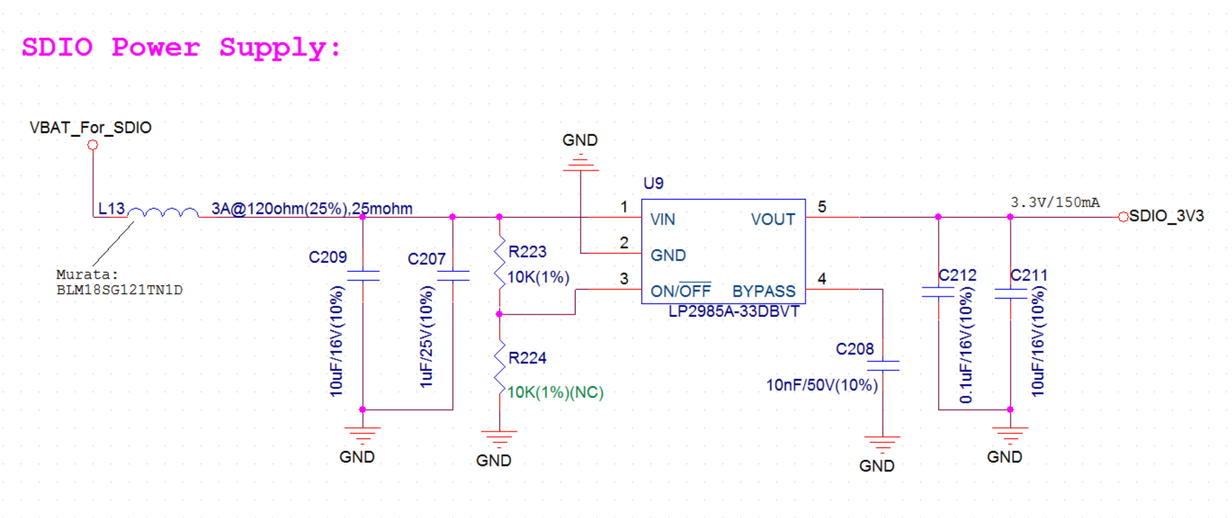


Fig. 18: ESP32 LyraT V4.3 - Dedicated LDO for the MicroSD Card

### Separate Power Feed for the PAs

The audio amplifier unit features two NS4150 that require a large power supply for driving external speakers with the maximum output power of 3W. The power is supplied directly to both PAs from the battery or the USB. The development board adds a set of LC circuits at the front of the PA power supply, where L uses 1.5A magnetic beads and C uses 10uF aluminum electrolytic capacitors, to effectively filter out power crosstalk.

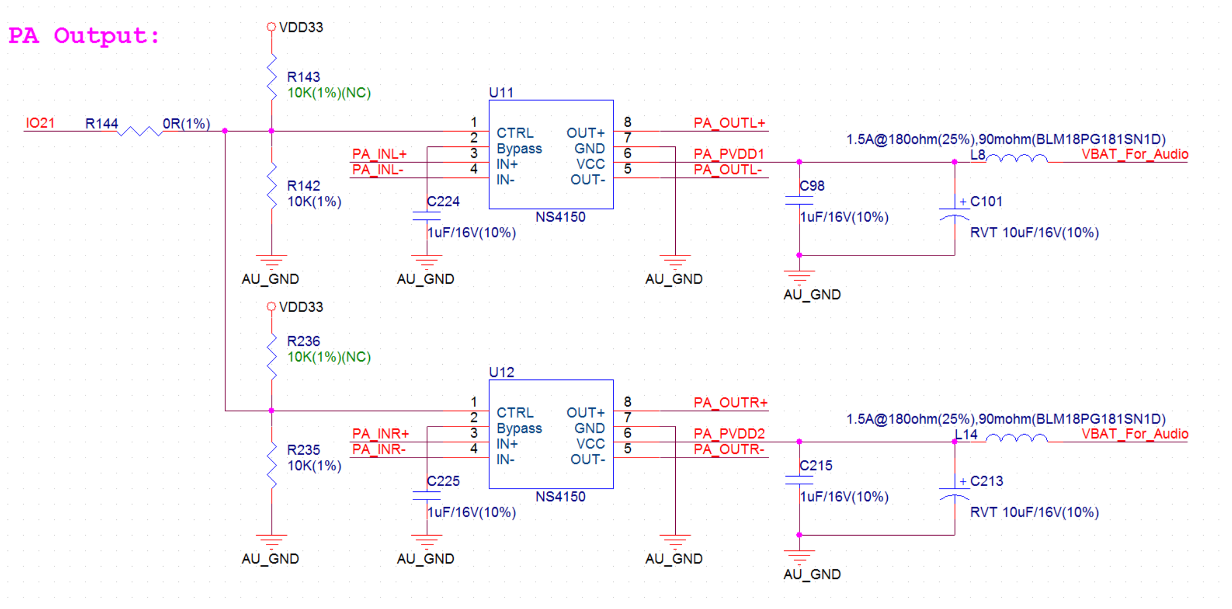


Fig. 19: ESP32 LyraT V4.3 - Power Supply for the PAs

### Selecting of the Audio Output

The development board uses two mono Class D amplifier ICs, model number NS4150 with maximum output power of 3W and operating voltage from 3.0V to 5.25V.

The audio input source is the digital-to-analog converter (DAC) output of the ES8388. Audio output supports two external speakers.

An optional audio output is a pair of headphones feed from the same DACs as the amplifier ICs.

To switch between using headphones and speakers, the board provides a digital input signal to detect when a headphone jack is inserted and a digital output signal to enable or disable the amplifier ICs. In other words selection between speakers and headphones is under software control instead of using mechanical contacts that would disconnect speakers once a headphone jack is inserted.

#### Other Versions of LyraT

- *ESP32-LyraT V4.2 Getting Started Guide*
- *ESP32-LyraT V4 Getting Started Guide*

#### Related Documents

- ESP32 LyraT V4.3 schematic (PDF)
- *ESP32-LyraT V4.3 Getting Started Guide*
- ESP32 Datasheet (PDF)
- ESP32-WROVER-E Datasheet (PDF)
- JTAG Debugging

### 3.4.5 ESP32-LyraT V4.2 Getting Started Guide

This guide provides users with functional descriptions, configuration options for ESP32-LyraT V4.2 audio development board, as well as how to get started with the ESP32-LyraT board.

The ESP32-LyraT development board is a hardware platform designed for the dual-core ESP32 audio applications, e.g., Wi-Fi or BT audio speakers, speech-based remote controllers, smart-home appliances with audio functionality(ies), etc.

If you like to start using this board right now, go directly to section *Start Application Development*.

#### What You Need

- 1 × *ESP32 LyraT V4.2 board*
- 2 × Speaker or headphones with a 3.5 mm jack. If you use a speaker, it is recommended to choose one no more than 3 watts, and JST PH 2.0 2-Pin plugs are needed. In case you do not have this type of plug it is also fine to use Dupont female jumper wires during development.
- 2 x Micro-USB 2.0 cables, Type A to Micro B
- 1 × PC loaded with Windows, Linux or Mac OS

#### Overview

The ESP32-LyraT V4.2 is an audio development board produced by Espressif built around ESP32. It is intended for audio applications, by providing hardware for audio processing and additional RAM on top of what is already onboard of the ESP32 chip. The specific hardware includes:

- **ESP32-WROVER Module**[*]
- **Audio Codec Chip**
- Dual **Microphones** on board
- **Headphone** input
- **2 x 3-watt Speaker** output
- Dual **Auxiliary Input**

- **MicroSD Card** slot (1 line or 4 lines)
- **Six buttons** (2 physical buttons and 4 touch buttons)
- **JTAG** header
- Integrated **USB-UART Bridge Chip**
- Li-ion **Battery-Charge Management**

The superscript * indicates that the product is in EOL status. The same applies below.

The block diagram below presents main components of the ESP32-LyraT and interconnections between components.

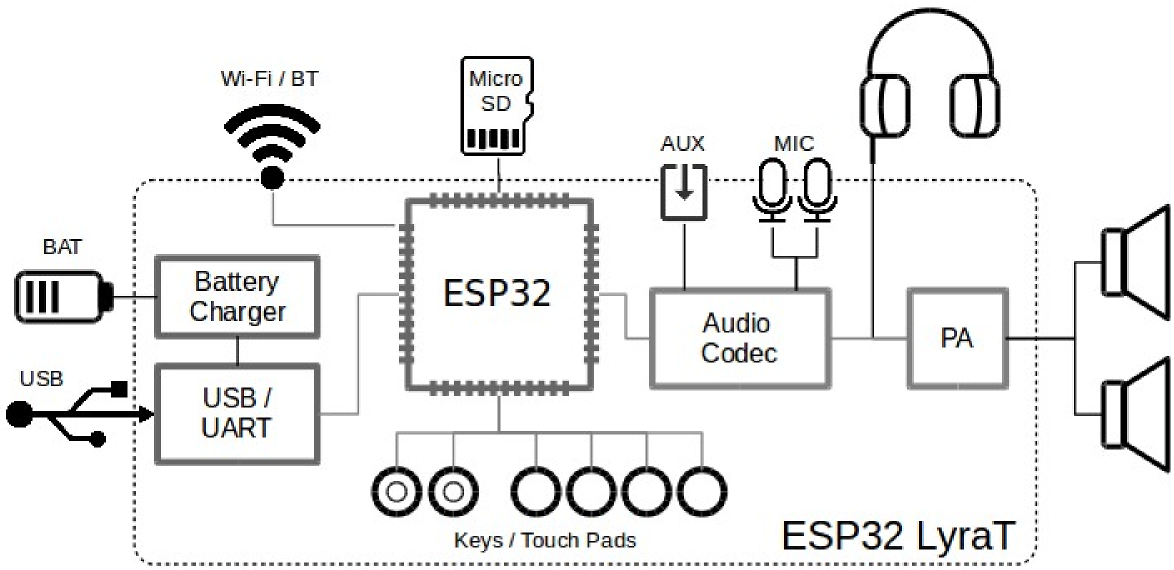


Fig. 20: ESP32-LyraT Block Diagram

### Functional Description

The following list and figure describe key components, interfaces and controls of the ESP32-LyraT board.

**ESP32-WROVER Module*** The ESP32-WROVER module* contains ESP32 chip to provide Wi-Fi / BT connectivity and data processing power as well as integrates 32 Mbit SPI flash and 32 Mbit PSRAM for flexible data storage.

**Green and Red LEDs** Two general purpose LEDs controlled by **ESP32-WROVER Module*** to indicate certain operation states of the audio application using dedicated API.

**Function DIP Switch** Used to configure function of GPIO12 to GPIO15 pins that are shared between devices, primarily between **JTAG Header** and **MicroSD Card**. By default, the **MicroSD Card** is enabled with all switches in *OFF* position. To enable the **JTAG Header** instead, switches in positions 3, 4, 5 and 6 should be put *ON*. If **JTAG** is not used and **MicroSD Card** is operated in the one-line mode, then GPIO12 and GPIO13 may be assigned to other functions. Please refer to ESP32 LyraT V4.2 schematic for more details.

**JTAG Header** Provides access to the **JTAG** interface of **ESP32-WROVER Module***. It may be used for debugging, application upload, as well as implementing several other functions, e.g., Application Level Tracing. See *JTAG Header / JP7* for pinout details. Before using **JTAG** signals to the header, **Function DIP Switch** should be enabled. Please note that when **JTAG** is in operation, **MicroSD Card** cannot be used and should be disconnected because some of JTAG signals are shared by both devices.

**UART Header** Serial port: provides access to the serial TX/RX signals between **ESP32-WROVER Module**[*] and **USB-UART Bridge Chip**.

**I2C Header** Provides access to the I2C interface. Both **ESP32-WROVER Module**[*] and **Audio Codec Chip** are connected to this interface. See *I2C Header / JP5* for pinout details.

**MicroSD Card** The development board supports a MicroSD card in SPI/1-bit/4-bit modes, and can store or play audio files in the MicroSD card. See *MicroSD Card / J5* for pinout details. Note that **JTAG** cannot be used and should be disconnected by setting **Function DIP Switch** when **MicroSD Card** is in operation, because some of signals are shared by both devices.

**I2S Header** Provides access to the I2S interface. Both **ESP32-WROVER Module**[*] and **Audio Codec Chip** are connected to this interface. See *I2S Header / JP4* for pinout details.

**Left Microphone** Onboard microphone connected to IN1 of the **Audio Codec Chip**.

**AUX Input** Auxiliary input socket connected to IN2 (left and right channel) of the **Audio Codec Chip**. Use a 3.5 mm stereo jack to connect to this socket.

**Headphone Output** Output socket to connect headphones with a 3.5 mm stereo jack.

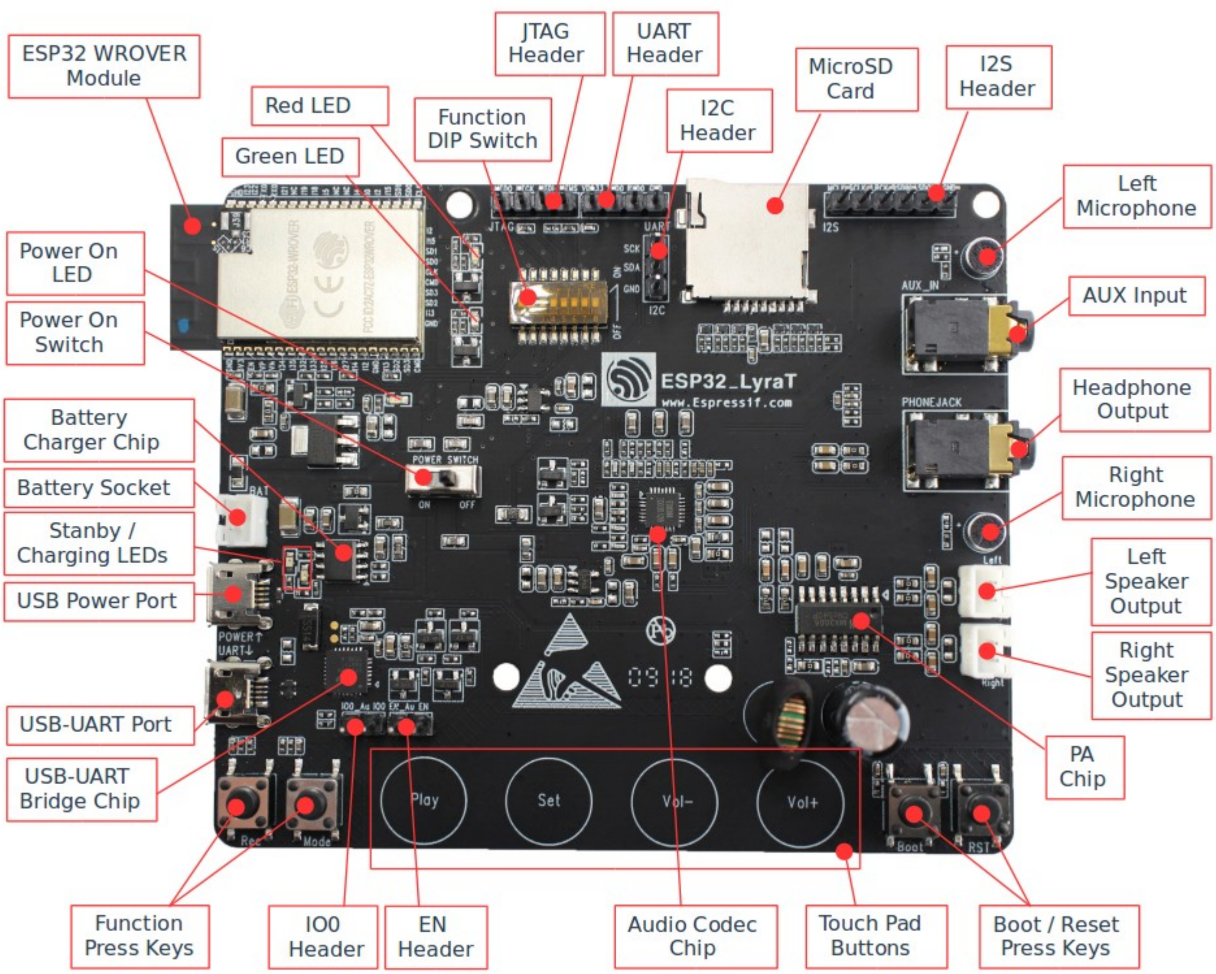


Fig. 21: ESP32-LyraT V4.2 Board Layout

**Right Microphone** Onboard microphone connected to IN1 of the **Audio Codec Chip**.

**Left Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**Right Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**PA Chip** A power amplifier used to amplify stereo audio signal from the **Audio Codec Chip** for driving two speakers.

**Boot/Reset Press Keys** Boot: holding down the **Boot** button and momentarily pressing the **Reset** button initiates the firmware upload mode. Then user can upload firmware through the serial port. Reset: pressing this button alone resets the system.

**Touch Pad Buttons** Four touch pads labeled *Play*, *Sel*, *Vol+* and *Vol-*. They are routed to **ESP32-WROVER Module*** and intended for development and testing of a UI for audio applications using dedicated API.

**Audio Codec Chip** The Audio Codec Chip, ES8388, is a low power stereo audio codec with a headphone amplifier. It consists of 2-channel ADC, 2-channel DAC, microphone amplifier, headphone amplifier, digital sound effects, analog mixing and gain functions. It is interfaced with **ESP32-WROVER Module*** over I2S and I2S buses to provide audio processing in hardware independently from the audio application.

**EN Header** Install a jumper on this header to enable automatic loading of application to the ESP32. Install or remove jumpers together on both IO0 and EN headers.

**IO0 Header** Install a jumper on this header to enable automatic loading of application to the ESP32. Install or remove jumpers together on both IO0 and EN headers.

**Function Press Keys** Two key labeled *Rec* and *Mode*. They are routed to **ESP32-WROVER Module*** and intended for developing and testing a UI for audio applications using dedicated API.

**USB-UART Bridge Chip** A single chip USB-UART bridge provides up to 1 Mbps transfers rate.

**USB-UART Port** Functions as the communication interface between a PC and the ESP32 module.

**USB Power Port** Provides the power supply for the board.

**Standby / Charging LEDs** The **Standby** green LED indicates that power has been applied to the **Micro USB Port**. The **Charging** red LED indicates that a battery connected to the **Battery Socket** is being charged.

**Battery Charger Chip** Constant current & constant voltage linear charger for single cell lithium-ion batteries AP5056. Used for charging of a battery connected to the **Battery Socket** over the **Micro USB Port**.

**Power On Switch** Power on/off knob: toggling it to the left powers the board on; toggling it to the right powers the board off.

**Battery Socket** Two pins socket to connect a single cell Li-ion battery.

**Power On LED** Red LED indicating that **Power On Switch** is turned on.

**Note:** The **Power On Switch** does not affect / disconnect the Li-ion battery charging.

### Hardware Setup Options

There are a couple of options to change the hardware configuration of the ESP32-LyraT board. The options are selectable with the **Function DIP Switch**.

#### Enable MicroSD Card in 1-wire Mode

| DIP SW | Position |
|---|---|
| 1 | OFF |
| 2 | OFF |
| 3 | OFF |
| 4 | OFF |
| 5 | OFF |
| 6 | OFF |
| 7 | OFF [1] |
| 8 | n/a |

1. **AUX Input** detection may be enabled by toggling the DIP SW 7 *ON*

In this mode:

- **JTAG** functionality is not available
- *Vol-* touch button is available for use with the API

#### Enable MicroSD Card in 4-wire Mode

| DIP SW | Position |
|---|---|
| 1 | ON |
| 2 | ON |
| 3 | OFF |
| 4 | OFF |
| 5 | OFF |
| 6 | OFF |
| 7 | OFF |
| 8 | n/a |

In this mode:

- **JTAG** functionality is not available
- *Vol-* touch button is not available for use with the API
- **AUX Input** detection from the API is not available

### Enable JTAG

| DIP SW | Position |
|---|---|
| 1 | OFF |
| 2 | OFF |
| 3 | ON |
| 4 | ON |
| 5 | ON |
| 6 | ON |
| 7 | ON |
| 8 | n/a |

In this mode:

- **MicroSD Card** functionality is not available, remove the card from the slot
- *Vol-* touch button is not available for use with the API
- **AUX Input** detection from the API is not available

### Allocation of ESP32 Pins

Several pins / terminals of ESP32 modules are allocated to the on board hardware. Some of them, like GPIO0 or GPIO2, have multiple functions. Please refer to the tables below or ESP32 LyraT V4.2 schematic for specific details.

### Red / Green LEDs

| | ESP32 Pin | LED Color |
|---|---|---|
| 1 | GPIO19 | Red LED |
| 2 | GPIO22 | Green LED |

### Touch Pads

| | ESP32 Pin | Touch Pad Function |
|---|---|---|
| 1 | GPIO33 | Play |
| 2 | GPIO32 | Set |
| 3 | GPIO13 | Vol- [1] |
| 4 | GPIO27 | Vol+ |

1. *Vol-* function is not available if **JTAG** is used. It is also not available for the **MicroSD Card** configured to operate in 4-wire mode.

### MicroSD Card / J5

| | ESP32 Pin | MicroSD Signal |
|---|---|---|
| 1 | MTDI / GPIO12 | DATA2 |
| 2 | MTCK / GPIO13 | CD / DATA3 |
| 3 | MTDO / GPIO15 | CMD |
| 4 | MTMS / GPIO14 | CLK |
| 5 | GPIO2 | DATA0 |
| 6 | GPIO4 | DATA1 |
| 7 | GPIO21 | CD |

### UART Header / JP2

| | Header Pin |
|---|---|
| 1 | 3.3V |
| 2 | TX |
| 3 | RX |
| 4 | GND |

### EN and IO0 Headers / JP23 and J24

| | ESP32 Pin | Header Pin |
|---|---|---|
| 1 | n/a | EN_Auto |
| 2 | EN | EN |

| | ESP32 Pin | Header Pin |
|---|---|---|
| 1 | n/a | IO0_Auto |
| 2 | GPIO0 | IO0 |

### I2S Header / JP4

| | I2C Header Pin | ESP32 Pin |
|---|---|---|
| 1 | MCLK | GPI0 |
| 2 | SCLK | GPIO5 |
| 1 | LRCK | GPIO25 |
| 2 | DSDIN | GPIO26 |
| 3 | ASDOUT | GPIO35 |
| 3 | GND | GND |

### I2C Header / JP5

| | I2C Header Pin | ESP32 Pin |
|---|---|---|
| 1 | SCL | GPIO23 |
| 2 | SDA | GPIO18 |
| 3 | GND | GND |

### JTAG Header / JP7

| | ESP32 Pin | JTAG Signal |
|---|---|---|
| 1 | MTDO / GPIO15 | TDO |
| 2 | MTCK / GPIO13 | TCK |
| 3 | MTDI / GPIO12 | TDI |
| 4 | MTMS / GPIO14 | TMS |

### Function DIP Switch / JP8

| | Switch OFF | Switch ON |
|---|---|---|
| 1 | GPIO12 not allocated | MicroSD Card 4-wire |
| 2 | Touch *Vol-* enabled | MicroSD Card 4-wire |
| 3 | MicroSD Card | JTAG |
| 4 | MicroSD Card | JTAG |
| 5 | MicroSD Card | JTAG |
| 6 | MicroSD Card | JTAG |
| 7 | MicroSD Card 4-wire | AUX IN detect [1] |
| 8 | not used | not used |

1. The **AUX Input** signal pin should not be be plugged in when the system powers up. Otherwise the ESP32 may not be able to boot correctly.

### Start Application Development

Before powering up the ESP32-LyraT, please make sure that the board has been received in good condition with no obvious signs of damage.

### Initial Setup

Prepare the board for loading of the first sample application:

1. Install jumpers on **IO0** and **EN** headers to enable automatic application upload. If there are no jumpers then upload may be triggered using **Boot / RST** buttons.
2. Connect speakers to the **Right** and **Left Speaker Output**.Connecting headphones to the **Headphone Output** is an option.
3. Plug in the Micro-USB cables to the PC and to **both USB ports** of the ESP32 LyraT.
4. The **Standby LED** (green) should turn on. Assuming that a battery is not connected, the **Charging LED** will blink every couple of seconds.

5. Toggle left the **Power On Switch**.
6. The red **Power On LED** should turn on.

If this is what you see on the LEDs, the board should be ready for application upload. Now prepare the PC by loading and configuring development tools what is discussed in the next section.

#### Develop Applications

Once the board is initially set up and checked, you can start preparing the development tools. The Section *Installation Step by Step* will walk you through the following steps:

- **Set up ESP-IDF** to get a common development framework for the ESP32 (and ESP32-S2) chips in C language;
- **Get ESP-ADF** to install the API specific to audio applications;
- **Set up env** to make the framework aware of the audio specific API;
- **Start a Project** that will provide a sample audio application for the board;
- **Connect Your Device** to prepare the application for loading;
- **Build the Project** to finally run the application and play some music.

#### Related Documents

- ESP32 LyraT V4.2 schematic (PDF)
- ESP32 Datasheet (PDF)
- JTAG Debugging
- *ESP32-LyraT V4 Getting Started Guide*

### 3.4.6 ESP32-LyraT V4 Getting Started Guide

This guide provide users with functional descriptions, configuration options for ESP32-LyraT V4 audio development board, as well as how to get started with ESP32-LyraT board.

The ESP32-LyraT development board is a hardware platform specifically designed for the dual-core ESP32 audio applications, e.g., Wi-Fi or BT audio speakers, speech-based remote controllers, smart-home appliances with audio functionality(ies), etc.

If you like to start using this board right now, go directly to section *Start Application Development*.

#### What You Need

- 1 × *ESP32-LyraT V4 board*
- 2 × Speaker or headphones with a 3.5 mm jack. If you use a speaker, it is recommended to choose one no more than 3 watts, and JST PH 2.0 2-Pin plugs are needed. In case you do not have this type of plug it is also fine to use Dupont female jumper wires during development.
- 1 × Micro USB 2.0 Cable, Type A to Micro B
- 1 × PC loaded with Windows, Linux or Mac OS

### Overview

The ESP32-LyraT V4 is an audio development board produced by Espressif built around ESP32. It is intended for audio applications, by providing hardware for audio processing and additional RAM on top of what is already onboard of the ESP32 chip. The specific hardware includes:

- **ESP32-WROVER Module***
- **Audio Codec Chip**
- Dual **Microphones** on board
- **Headphone** input
- **2 x 3 Watt Speaker** output
- Dual **Auxiliary Input**
- **MicroSD Card** slot (1 line or 4 lines)
- **6 buttons** (2 physical buttons and 4 touch buttons)
- **JTAG** header
- Integrated **USB-UART Bridge Chip**
- Li-ion **Battery-Charge Management**

The superscript * indicates that the product is in EOL status. The same applies below.

The block diagram below presents main components of the ESP32-LyraT and interconnections between components.

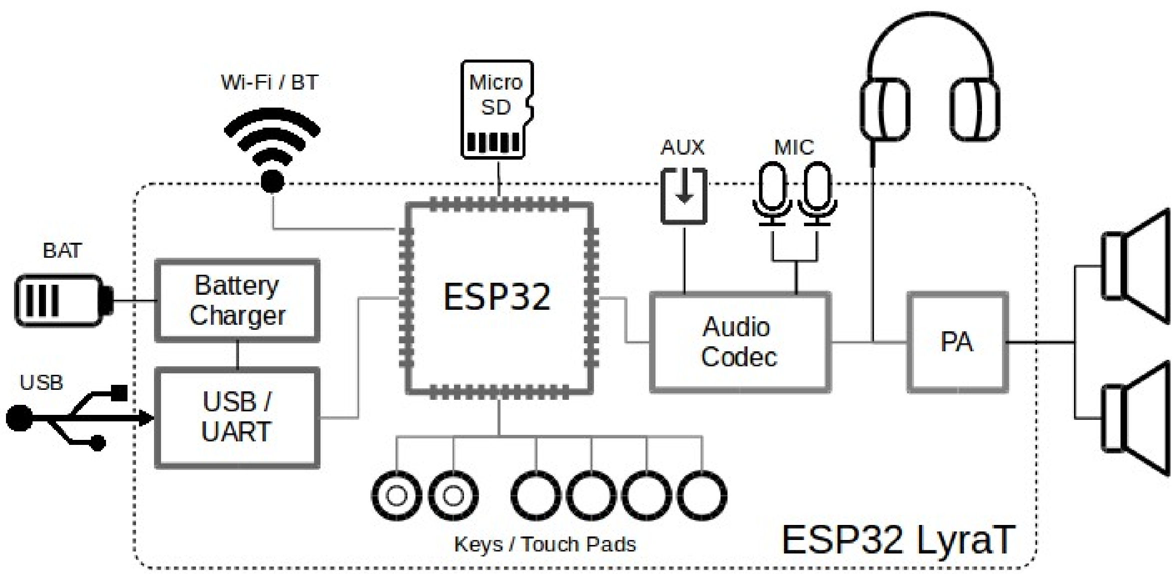


Fig. 22: ESP32-LyraT block diagram

### Functional Description

The following list and figure below describe key components, interfaces and controls of the ESP32-LyraT board.

**ESP32-WROVER Module*** The ESP32-WROVER* module contains ESP32 chip to provide Wi-Fi / BT connectivity and data processing power as well as integrates 32 Mbit SPI flash and 32 Mbit PSRAM for flexible data storage.

**Green and Red LEDs** Two general purpose LEDs controlled by **ESP32-WROVER Module*** to indicate certain operation states of the audio application using dedicated API.

**Function DIP Switch** Used to configure function of GPIO12 to GPIO15 pins that are shared between devices, primarily between **JTAG Header** and **MicroSD Card**. By default **MicroSD Card** is enabled with all switches in *OFF* position. To enable **JTAG Header** instead, switches in positions 3, 4, 5 and 6 should be put *ON*. If **JTAG** is not used and **MicroSD Card** is operated in one-line mode, then GPIO12 and GPIO13 may be assigned to other functions. Please refer to ESP32 LyraT V4 schematic for more details.

**JTAG Header** Provides access to the **JTAG** interface of **ESP32-WROVER Module***. May be used for debugging, application upload, as well as implementing several other functions, e.g., Application Level Tracing. See *JTAG Header / JP7* for pinout details. Before using **JTAG** signals to the header, **Function DIP Switch** should be enabled. Please note that when **JTAG** is in operation, **MicroSD Card** cannot be used and should be disconnected because some of JTAG signals are shared by both devices.

**UART Header** Serial port provides access to the serial TX/RX signals between **ESP32-WROVER Module*** and **USB-UART Bridge Chip**.

**I2C Header** Provides access to the I2C interface. Both **ESP32-WROVER Module*** and **Audio Codec Chip** are connected to this interface. See *I2C Header / JP5* for pinout details.

**MicroSD Card** The development board supports a MicroSD card in SPI/1-bit/4-bit modes, and can store or play audio files in the MicroSD card. See *MicroSD Card / J5* for pinout details. Note that **JTAG** cannot be used and should be disconnected by setting **Function DIP Switch** when **MicroSD Card** is in operation, because some of the signals are shared by both devices.

**I2S Header** Provides access to the I2S interface. Both **ESP32-WROVER Module*** and **Audio Codec Chip** are connected to this interface. See *I2S Header / JP4* for pinout details.

**Left Microphone** Onboard microphone connected to IN1 of the **Audio Codec Chip**.

**AUX Input** Auxiliary input socket connected to IN2 (left and right channels) of the **Audio Codec Chip**. Use a 3.5 mm stereo jack to connect to this socket.

**Headphone Output** Output socket to connect headphones with a 3.5 mm stereo jack.

**Right Microphone** Onboard microphone connected to IN1 of the **Audio Codec Chip**.

**Left Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08” pitch.

**Right Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08” pitch.

**PA Chip** A power amplifier used to amplify stereo audio signal from the **Audio Codec Chip** for driving two speakers.

**Boot/Reset Press Keys** Boot: holding down the **Boot** button and momentarily pressing the **Reset** button initiates the firmware upload mode. Then user can upload firmware through the serial port. Reset: pressing this button alone resets the system.

**Touch Pad Buttons** Four touch pads labeled *Play*, *Sel*, *Vol+* and *Vol-*. They are routed to **ESP32-WROVER Module*** and intended for development and testing of a UI for audio applications using dedicated API.

**Audio Codec Chip** The Audio Codec Chip, ES8388, is a low-power stereo audio codec with headphone amplifier. It consists of 2-channel ADC, 2-channel DAC, microphone amplifier, headphone amplifier, digital sound effects,

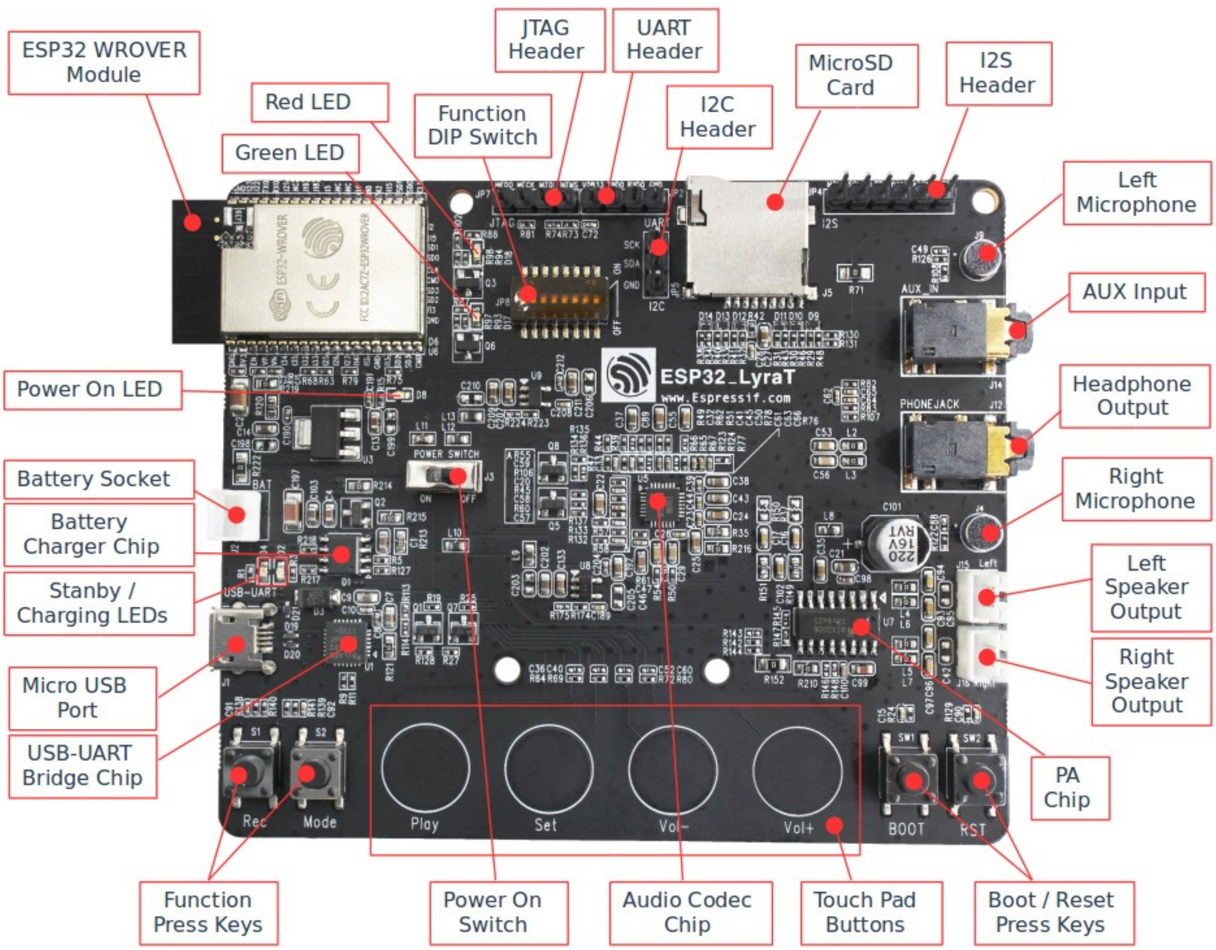


Fig. 23: ESP32 LyraT V4 board layout

analog mixing and gain functions. It is interfaced with **ESP32-WROVER Module*** over I2S and I2S buses to provide audio processing in hardware independently from the audio application.

**Function Press Keys** Two key labeled *Rec* and *Mode*. They are routed to **ESP32-WROVER Module*** and intended for developing and testing a UI for audio applications using dedicated API.

**USB-UART Bridge Chip** A single chip USB-UART bridge provides up to 1 Mbps transfer rate.

**Micro USB Port** USB interface. It functions as the power supply for the board and the communication interface between a PC and the ESP32 module.

**Standby / Charging LEDs** The **Standby** green LED indicates that power has been applied to the **Micro USB Port**. The **Charging** red LED indicates that a battery connected to the **Battery Socket** is being charged.

**Battery Charger Chip** Constant current & constant voltage linear charger for single cell lithium-ion batteries AP5056. Used for charging of a battery connected to the **Battery Socket** over the **Micro USB Port**.

**Power On Switch** Power on/off knob: toggling it to the left powers the board on; toggling it to the right powers the board off.

**Battery Socket** Two pins socket to connect a single cell Li-ion battery.

**Power On LED** Red LED indicating that **Power On Switch** is turned on.

**Note:** The **Power On Switch** does not affect / disconnect the Li-ion battery charging.

### Hardware Setup Options

There are couple of options to change the hardware configuration of the ESP32-LyraT board. The options are selectable with the **Function DIP Switch**.

### Enable MicroSD Card in 1-wire Mode

| DIP SW | Position |
|---|---|
| 1 | OFF |
| 2 | OFF |
| 3 | OFF |
| 4 | OFF |
| 5 | OFF |
| 6 | OFF |
| 7 | OFF [1] |
| 8 | n/a |

1. **AUX Input** detection may be enabled by toggling the DIP SW 7 *ON*

In this mode:

- **JTAG** functionality is not available
- *Vol-* touch button is available for use with the API

### Enable MicroSD Card in 4-wire Mode

| DIP SW | Position |
|---|---|
| 1 | ON |
| 2 | ON |
| 3 | OFF |
| 4 | OFF |
| 5 | OFF |
| 6 | OFF |
| 7 | OFF |
| 8 | n/a |

In this mode:

- **JTAG** functionality is not available
- *Vol-* touch button is not available for use with the API
- **AUX Input** detection from the API is not available

### Enable JTAG

| DIP SW | Position |
|---|---|
| 1 | OFF |
| 2 | OFF |
| 3 | ON |
| 4 | ON |
| 5 | ON |
| 6 | ON |
| 7 | ON |
| 8 | n/a |

In this mode:

- **MicroSD Card** functionality is not available, remove the card from the slot
- *Vol-* touch button is not available for use with the API
- **AUX Input** detection from the API is not available

### Allocation of ESP32 Pins

Several pins / terminals of ESP32 modules are allocated to the onboard hardware. Some of them, like GPIO0 or GPIO2, have multiple functions. Please refer to tables below or ESP32 LyraT V4 schematic for specific details.

### Red / Green LEDs

| | ESP32 Pin | LED Color |
|---|---|---|
| 1 | GPIO19 | Red LED |
| 2 | GPIO22 | Green LED |

### Touch Pads

| | ESP32 Pin | Touch Pad Function |
|---|---|---|
| 1 | GPIO33 | Play |
| 2 | GPIO32 | Set |
| 3 | GPIO13 | Vol- [1] |
| 4 | GPIO27 | Vol+ |

1. *Vol-* function is not available if **JTAG** is used. It is also not available for the **MicroSD Card** configured to operate in 4-wire mode.

### MicroSD Card / J5

| | ESP32 Pin | MicroSD Signal |
|---|---|---|
| 1 | MTDI / GPIO12 | DATA2 |
| 2 | MTCK / GPIO13 | CD / DATA3 |
| 3 | MTDO / GPIO15 | CMD |
| 4 | MTMS / GPIO14 | CLK |
| 5 | GPIO2 | DATA0 |
| 6 | GPIO4 | DATA1 |
| 7 | GPIO21 | CD |

### UART Header / JP2

| | Header Pin |
|---|---|
| 1 | 3.3V |
| 2 | TX |
| 3 | RX |
| 4 | GND |

### I2S Header / JP4

| | I2C Header Pin | ESP32 Pin |
|---|---|---|
| 1 | MCLK | GPI0 |
| 2 | SCLK | GPIO5 |
| 1 | LRCK | GPIO25 |
| 2 | DSDIN | GPIO26 |
| 3 | ASDOUT | GPIO35 |
| 3 | GND | GND |

### I2C Header / JP5

| | I2C Header Pin | ESP32 Pin |
|---|---|---|
| 1 | SCL | GPIO23 |
| 2 | SDA | GPIO18 |
| 3 | GND | GND |

### JTAG Header / JP7

| | ESP32 Pin | JTAG Signal |
|---|---|---|
| 1 | MTDO / GPIO15 | TDO |
| 2 | MTCK / GPIO13 | TCK |
| 3 | MTDI / GPIO12 | TDI |
| 4 | MTMS / GPIO14 | TMS |

### Function DIP Switch / JP8

| | Switch OFF | Switch ON |
|---|---|---|
| 1 | GPIO12 not allocated | MicroSD Card 4-wire |
| 2 | Touch *Vol-* enabled | MicroSD Card 4-wire |
| 3 | MicroSD Card | JTAG |
| 4 | MicroSD Card | JTAG |
| 5 | MicroSD Card | JTAG |
| 6 | MicroSD Card | JTAG |
| 7 | MicroSD Card 4-wire | AUX IN detect [1] |
| 8 | not used | not used |

1. The **AUX Input** signal pin should not be plugged in when the system powers up. Otherwise the ESP32 may not be able to boot correctly.

### Start Application Development

Before powering up the ESP32-LyraT, please make sure that the board has been received in good condition with no obvious signs of damage.

### Initial Setup

Prepare the board for loading of the first sample application:

1. Connect speakers to the **Right** and **Left Speaker Output**. Optionally connect headphones to the **Headphone Output**.
2. Plug in the Micro-USB cable to the PC and to the **Micro USB Port** of the ESP32-LyraT.
3. The **Standby LED** (green) should turn on. Assuming that a battery is not connected, the **Charging LED** will momentarily blink every couple of seconds.
4. Toggle left the **Power On Switch**.

5. The red **Power On LED** should turn on.

If this is what you see on the LEDs, the board should be ready for application upload. Now prepare the PC by loading and configuring development tools what is discussed in the next section.

### Develop Applications

Once the board is initially set up and checked, you can start preparing the development tools. The Section *Installation Step by Step* will walk you through the following steps:

- **Set up ESP-IDF** to get a common development framework for the ESP32 (and ESP32-S2) chips in C language;
- **Get ESP-ADF** to install the API specific to audio applications;
- **Set up env** to make the framework aware of the audio specific API;
- **Start a Project** that will provide a sample audio application for the board;
- **Connect Your Device** to prepare the application for loading;
- **Build the Project** to finally run the application and play some music.

### Related Documents

- ESP32 LyraT V4 schematic (PDF)
- ESP32 Datasheet (PDF)
- JTAG Debugging

## 3.4.7 ESP32-LyraTD-MSC V2.2 Getting Started Guide

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This guide provides users with functional descriptions, configuration options for ESP32-LyraTD-MSC V2.2 audio development board, as well as how to get started with the ESP32-LyraTD-MSC board.

The ESP32-LyraTD-MSC is a hardware platform designed for smart speakers and AI applications. It supports Acoustic Echo Cancellation (AEC), Automatic Speech Recognition (ASR), Wake-up Interrupt and Voice Interaction.

### What You Need

- 1 × *ESP32-LyraTD-MSC V2.2 board*
- 2 x Speaker or headphones with a 3.5 mm jack. If you use a speaker, it is recommended to choose one no more than 3 watts, and JST PH 2.0 2-Pin plugs are needed. In case you do not have this type of plug it is also fine to use Dupont female jumper wires during development.
- 2 x Micro-USB 2.0 cables, Type A to Micro B
- 1 × PC loaded with Windows, Linux or Mac OS

If you like to start using this board right now, go directly to section *Start Application Development*.

### Overview

The ESP32-LyraTD-MSC V2.2 is an audio development board produced by Espressif built around ESP32. It is intended for smart speakers and AI applications, by providing hardware for digital signal processing, microphone array and additional RAM on top of what is already onboard of the ESP32 chip.

This audio development board consists of two parts: the upper board (B), which provides a three-microphone array, function keys and LED lights; and the lower board (A), which integrates ESP32-WROVER-E, a MicroSemi Digital Signal Processing (DSP) chip, and a power management module.


Fig. 24: ESP32-LyraTD-MSC Side View

The specific hardware includes:

- ESP32-WROVER-E Module
- DSP (Digital Signal Processing) chip
- Three digital Microphones that support far-field voice pick-up
- 2 x 3-watt Speaker output
- Headphone output
- MicroSD Card slot (1 line or 4 lines)
- Individually controlled Twelve LEDs distributed in a circle on the board's edge
- Six Function Buttons that may be assigned user functions
- Several interface ports: I2S, I2C, SPI and JTAG
- Integrated USB-UART Bridge Chip
- Li-ion Battery-Charge Management

The block diagram below presents main components of the ESP32-LyraTD-MSC and interconnections between components.

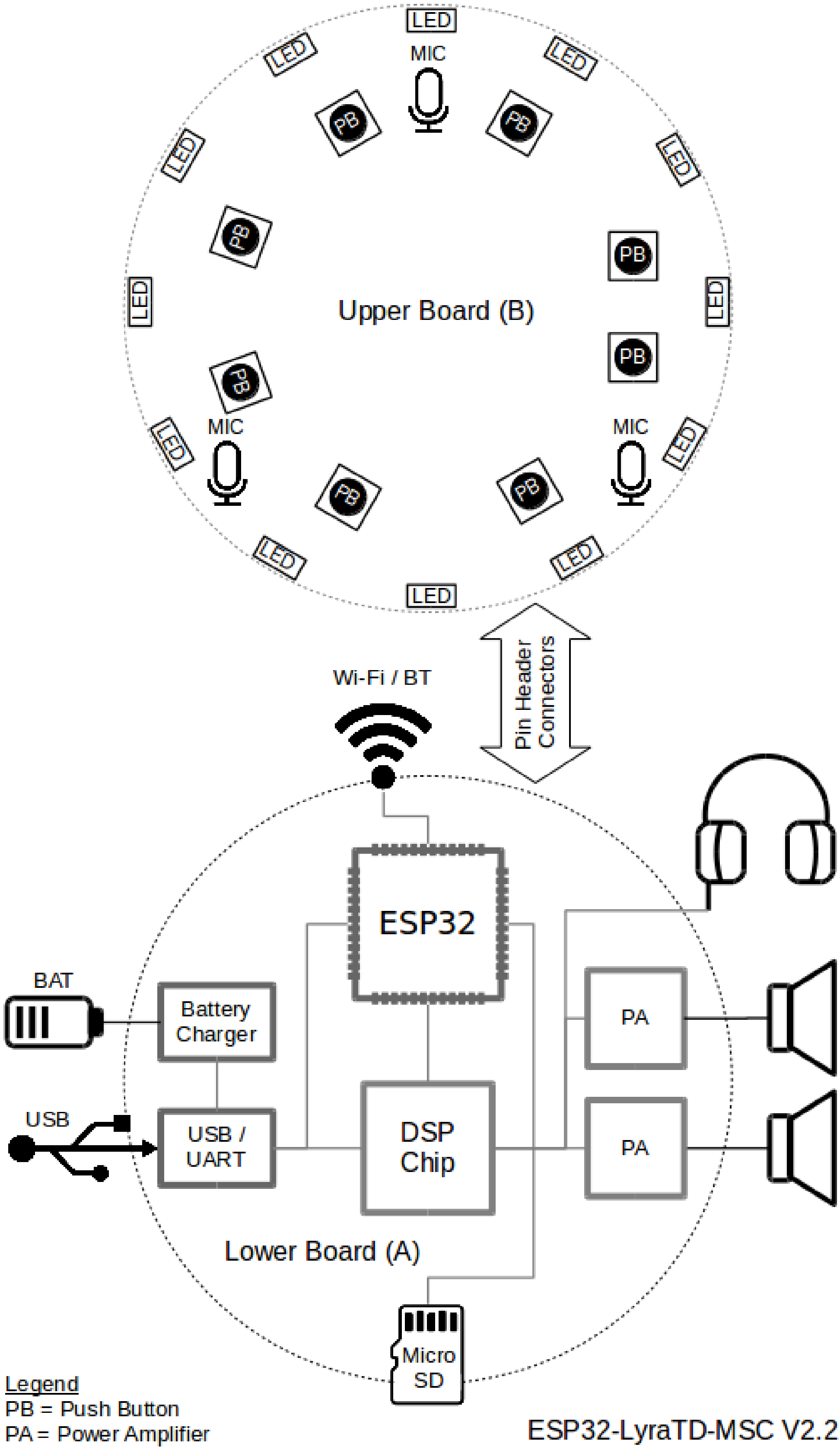


Fig. 25: ESP32-LyraTD-MSC Block Diagram

### Components

The following list and figure describe key components, interfaces and controls of the ESP32-LyraTD-MSC used in this guide. This covers just what is needed now. For additional details please refer to schematics provided in *Related Documents*.

**ESP32-WROVER-E Module** The ESP32-WROVER-E module contains ESP32 chip to provide Wi-Fi / Bluetooth connectivity and data processing power as well as integrates 4 MB external SPI flash and an additional 8 MB PSRAM for flexible data storage.

**DSP Chip** The Digital Signal Processing chip ZL38063 is used for Automatic Speech Recognition (ASR) applications. It captures audio data from an external microphone array and outputs audio signals through its Digital-to-Analog-Converter (DAC) port.

**Headphone Output** Output socket to connect headphones with a 3.5 mm stereo jack.

> **Note:** The socket may be used with mobile phone headsets and is compatible with OMPT standard headsets only. It does not work with CTIA headsets. Please refer to Phone connector (audio) on Wikipedia.

**Left Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

**Right Speaker Output** Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm / 0.08" pitch.

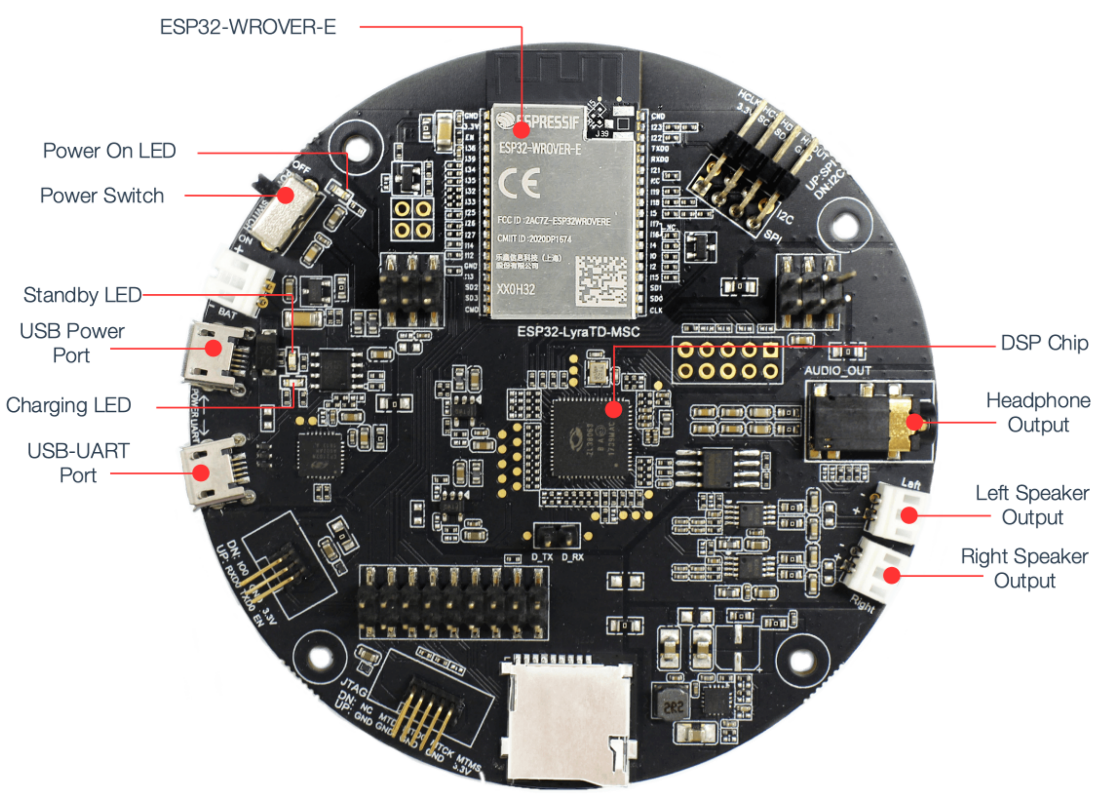


Fig. 26: ESP32-LyraTD-MSC V2.2 Lower Board (A) Components

**USB-UART Port** Functions as the communication interface between a PC and the ESP32-WROVER-E module.

**USB Power Port** Provides the power supply for the board.

**Standby / Charging LEDs** The **Standby** green LED indicates that power has been applied to the **Micro USB Port**. The **Charging** red LED indicates that a battery connected to the **Battery Socket** is being charged.

**Power Switch** Power on/off knob: toggling it right powers the board on; otherwise powers the board off.

**Power On LED** Red LED indicating that **Power Switch** is turned on.

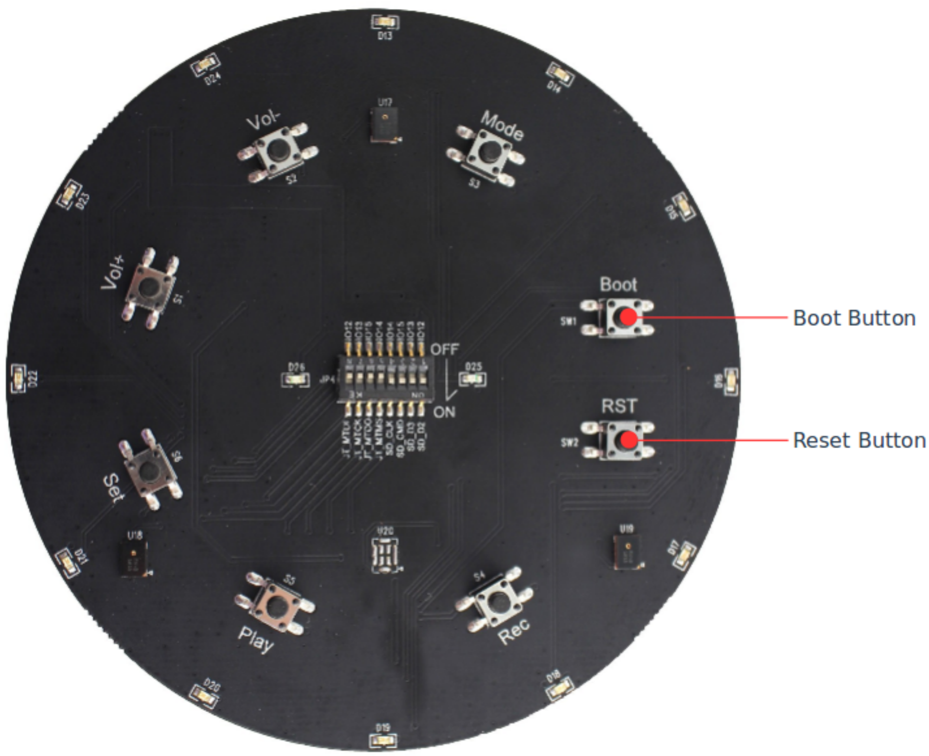


Fig. 27: ESP32-LyraTD-MSC V2.2 Upper Board (B) Components

**Boot/Reset Buttons** Boot: holding down the **Boot** button and momentarily pressing the **Reset** button initiates the firmware upload mode. Then user can upload firmware through the serial port.

Reset: pressing this button alone resets the system.

### Start Application Development

Before powering up the ESP32-LyraTD-MSC, please make sure that the board has been received in good condition with no obvious signs of damage. Both the lower A and the upper B board of the ESP32-LyraTD-MSC should be firmly connected together.

### Initial Setup

Prepare the board for loading of the first sample application:

1. Connect speakers to the **Right** and **Left Speaker Output**. Connecting headphones to the **Headphone Output** is an option.
2. Plug in the Micro-USB cables to the PC and to **both USB ports** of the ESP32-LyraTD-MSC.
3. The **Standby LED** (green) should turn on. Assuming that a battery is not connected, the **Charging LED** (red) will blink every couple of seconds.
4. Toggle right the **Power Switch**.
5. The red **Power On LED** should turn on.

If this is what you see on the LEDs, the board should be ready for application upload. Now prepare the PC by loading and configuring development tools what is discussed in the next section.

### Develop Applications

Once the board is initially set up and checked, you can start preparing the development tools. The Section *Installation Step by Step* will walk you through the following steps:

- **Set up ESP-IDF** to get a common development framework for the ESP32 (and ESP32-S2) chips in C language;
- **Get ESP-ADF** to install the API specific to audio applications;
- **Set up env** to make the framework aware of the audio specific API;
- **Start a Project** that will provide a sample audio application for the board;
- **Connect Your Device** to prepare the application for loading;
- **Build the Project** to finally run the application and play some music.

### Revision History

- Changed the integrated module to ESP32-WROVER-E from ESP32-WROVER-B.

### Other Boards from LyraT Family

- *ESP32-LyraT V4.3 Getting Started Guide*
- *ESP32-LyraT-Mini V1.2 Getting Started Guide*

### Related Documents

- ESP32-LyraTD-MSC V2.2 Schematic Lower Board (A) (PDF)
- ESP32-LyraTD-MSC V2.2 Schematic Upper Board (B) (PDF)
- ESP32 Datasheet (PDF)
- ESP32-WROVER-E Datasheet (PDF)

### 3.4.8 ESP32-Korvo-DU1906

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This user guide provides information on ESP32-Korvo-DU1906.

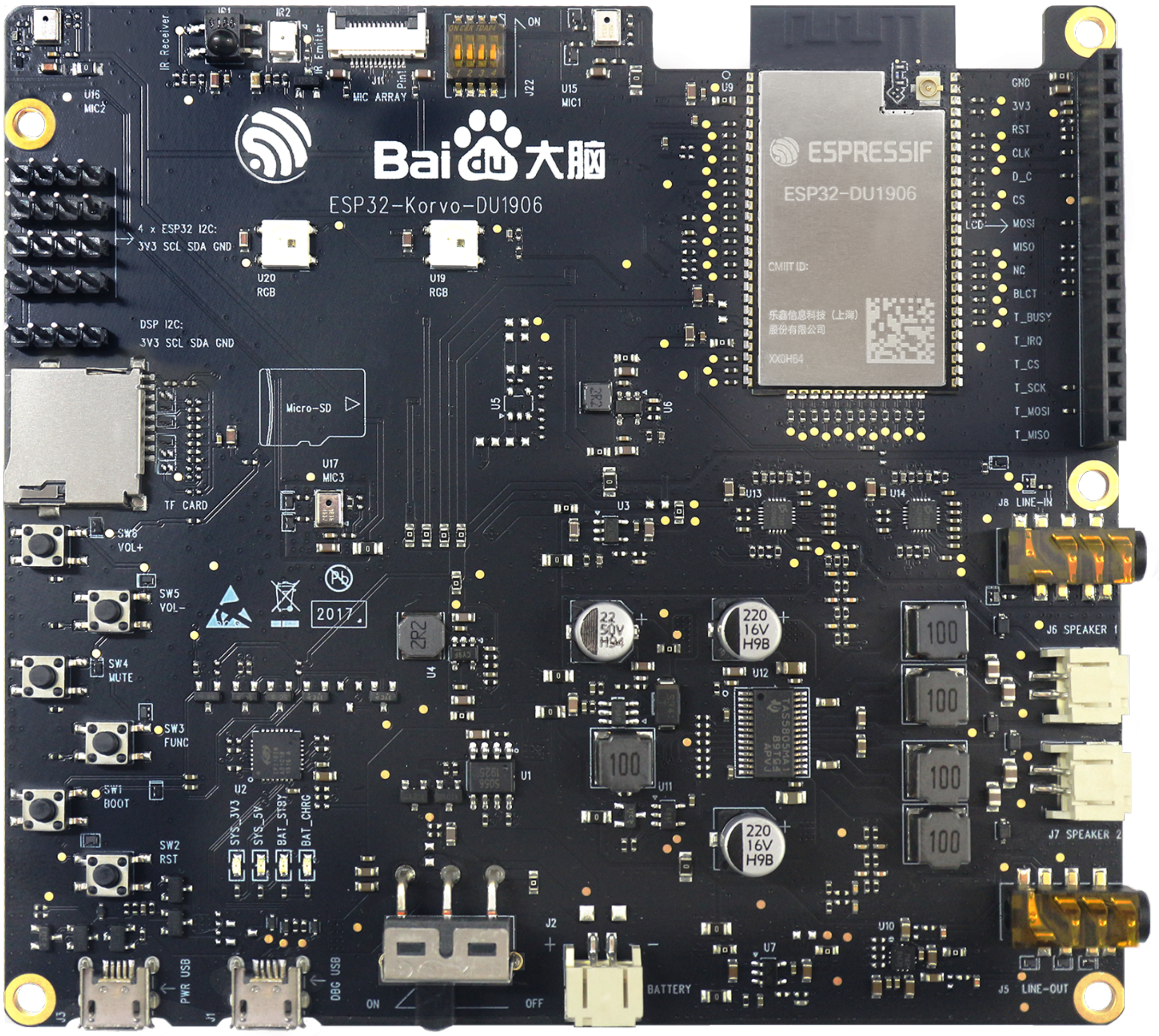


Fig. 28: ESP32-Korvo-DU1906 (click to enlarge)

The document consists of the following major sections:

- *Getting Started*: Provides an overview of the ESP32-Korvo-DU1906 and hardware/software setup instructions to get started.
- *Start Application Development*: Provides more detailed information about the ESP32-Korvo-DU1906's application development process.
- *Related Documents*: Gives links to related documentaiton.

### Getting Started

The core component of ESP32-Korvo-DU1906 includes an ESP32-DU1906 Bluetooth/Wi-Fi audio module, which is able to realize noise reduction, acoustic echo cancellation (AEC), beam formation and detection. ESP32-Korvo-DU1906 integrates power management, Bluetooth/Wi-Fi audio module, Coder-Decoder (CODEC), power amplifier, and etc., supports various functions such as:

- ADC
- Microphone array
- SD card
- Functional buttons
- Indicator lights
- Battery constant-current/constant-voltage linear power management chip
- USB-to-UART conversion
- LCD connector

### What You Need

- 1 x PC loaded with Windows, Mac OS and Linux (Linux Operating System is recommended)
- 1 x ESP32-Korvo-DU1906
- 2 x Micro USB cables
- 2 x Speaker (4 Ohm, 2.5 W)

### Overview

The biggest advantage of this development board is the audio chip – ESP32-DU1906, the core processing module, is an powerful AI module integrating Wi-Fi+Bluetooth+Bluetooth Low Energy RF and voice/speech signal processing functions, which can be used in various fields. By providing the leading end-to-end audio solutions, high-efficient integrated AI service capabilities, and an on-device AIOT platform which integrates ends and devices, this board is able to largely reduce the threshold for AI access.

DU1906 is a voice processing flagship chip launched by Baidu. This chip has a highly integrated algorithm, which can solve the industrial needs of real-time processing of far-field array signals, and high-precision voice wake-up and real-time monitoring with ultra-low error occurs simultaneously on this single one chip.

The block diagram below presents main components of the ESP32-Korvo-DU1906 and interconnections between components.

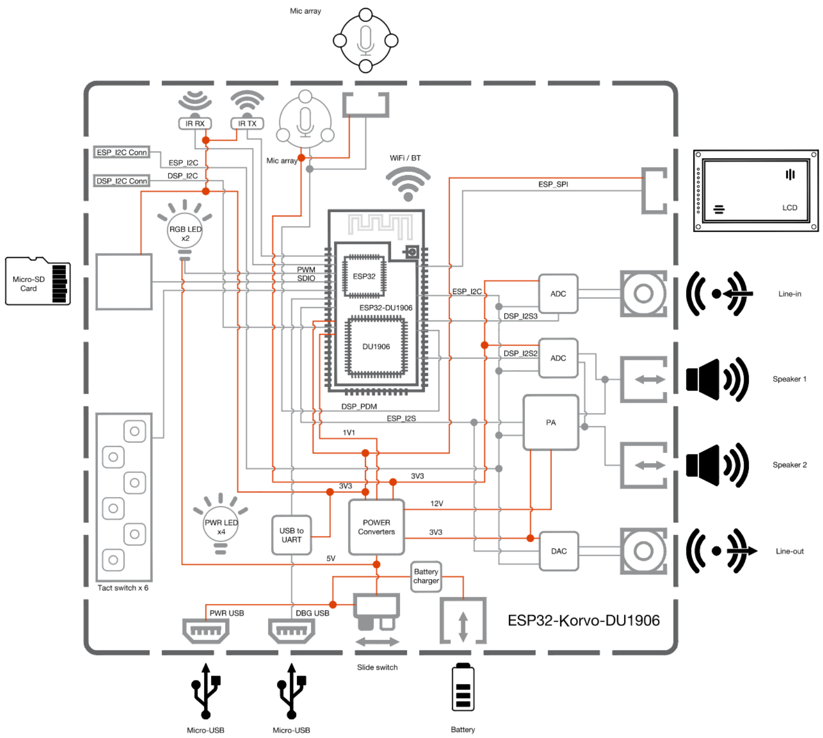


Fig. 29: ESP32-Korvo-DU1906 Block Diagram (click to enlarge)

## Description of Components

The following list and figure describe key components, interfaces and controls of the ESP32-Korvo-DU1906 used in this guide. This covers just what is needed now. For additional details please refer to schematics provided in Related Documents.

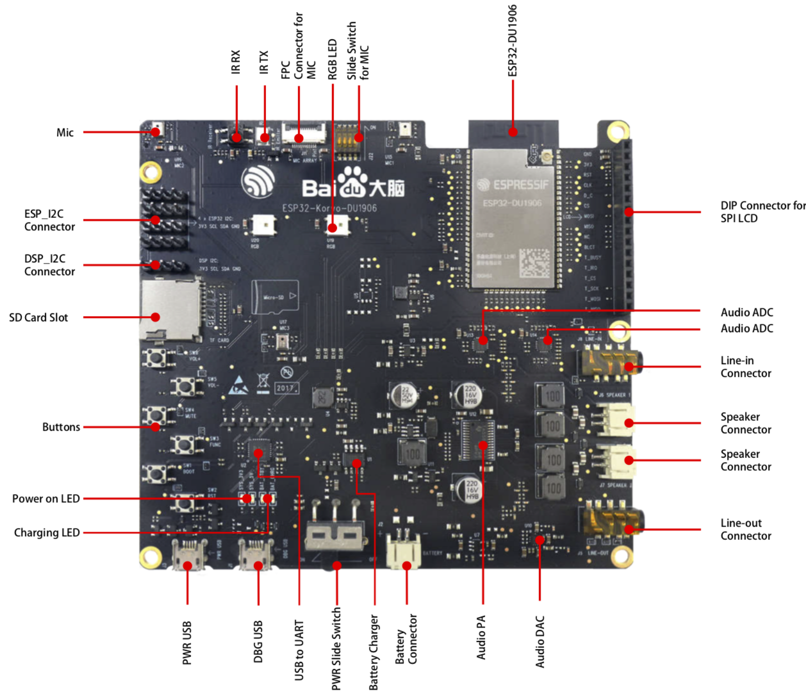


Fig. 30: ESP32-Korvo-DU1906 Components (click to enlarge)

| Key Componenet | Description |
|---|---|
| ESP32-DU1906 | This is a powerful, general-purpose, Wi-Fi/Bluetooth audio communication module, targeting a wide variety of applications ranging from low-power sensor networks to the most demanding tasks, such as voice encoding/decoding, music streaming and running voice assistant client SDK. |
| DIP Connector for SPI LCD | ESP32-Korvo-DU1906 has a 2.54 mm pitch connector to connect SPI LCD. |
| Audio ADC (Audio Analog-to-Digital Converter) | ESP32-Korvo-DU1906 includes two ES7243 high-efficiency ADCs, with one for the collection of Audio PA outputs, and another for the collection of Line-in outputs. Both ADCs can be used for AEC. |
| Line-in/out Connector (Earphone Jacks) | The two earphone jacks are used to connect to Line-out outputs of Audio DAC and Line-in inputs of Audio ADC respectively. When a device is plugged in the Line-out earphone jack of Audio DAC, the Audio PA on the ESP32-Korvo-DU1906 will be turned off. |
| Speaker Connector | Output sockets to connect two 4-ohm speakers to provide stereo sound via digital Audio PA. |
| Audio DAC (Audio Digital-to-Analog Converter) | ES7148 Stereo DAC is able to convert digital signals into analog audio outputs. |
| Audio PA (Digital Audio Power Amplifier) | TAS5805M is a high-efficiency stereo closed-loop D-type amplifier with low power dissipation and rich sound. It can convert audio digital signals into high-power analog audio outputs and transmit them to external speakers for playback. When the Line-out earphone jack of the audio DAC plugged into the device, the Digital Audio PA on the ESP32-Korvo-DU1906 will be turned off. |
| Battery Connector | Connect a battery. |
| Battery Charger | AP5056, a constant-current/constant-voltage linear power management chip, can be used for charging management to a single lithium-ion battery. |
| PWR Slide Switch | Power switch for the board, turn on/off the power supply. |
| USB to UART | CP2102N supports USB-to-UART conversion for easy download and debugging of software. |
| DBG USB (Debugging USB) | USB communication between PC and ESP32-DU1906 module. |
| PWR USB (Power supply USB) | Provide power supply for the whole system. It is recommended that the system should be connected to an at least 5 V / 2 A power adapter for sufficient current supply. |
| Charging LEDs | Indicating battery state. When a battery is connected, BAT_CHRG LED will turn red (indicating the battery is charging), then BAT_STBY LED will turn |

#### Start Application Development

Before powering up the ESP32-Korvo-DU1906, please make sure that the board has been received in good condition with no obvious signs of damage.

#### Initial Setup

Prepare the board for loading of the first sample application:

1. Connect 4-ohm speakers to the two **Speaker Connectors**. Connecting earphones to the **Line-out Connector** is an option.
2. Plug in the Micro-USB cables to the PC and to both **USB connectors** of the ESP32-Korvo-DU1906.
3. Assuming that a battery is connected, the **Charging LED** (red) will keep the lights on.
4. Toggle left the **PWR Slide Switch**.
5. The red **Power On LED** should turn on.

If this is what you see on the LEDs, the board should be ready for application upload. Now prepare the PC by loading and configuring development tools what is discussed in the next section.

#### Develop Applications

Once the board is initially set up and checked, you can start preparing the development tools. The Section *Development Boards* will walk you through the following steps:

- **Set up ESP-IDF** to get a common development framework for the ESP32 (and ESP32-S2) chips in C language;
- **Get ESP-ADF** to install the API specific to audio applications;
- **Set up env** to make the framework aware of the audio specific API;
- **Start a Project** that will provide a sample audio application for the board;
- **Connect Your Device** to prepare the application for loading;
- **Build the Project** to finally run the application and play some music.

#### Other Related Boards

- *ESP32-LyraT V4.3 Getting Started Guide*
- *ESP32-LyraT-Mini V1.2 Getting Started Guide*
- *ESP32-LyraTD-MSC V2.2 Getting Started Guide*

### Contents and Packaging

### Retail orders

If you order one or several samples, each board will come in a plastic package or other package chosen by the retailer.

For retail orders, please go to https://www.espressif.com/zh-hans/products/devkits/esp32-korvo-du1906.

### Related Documents

- ESP32-Korvo-DU1906 Schematic (PDF)
- ESP32 Datasheet (PDF)

## 3.4.9 ESP32-S3-Korvo-2 V3.0

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This user guide will help you get started with ESP32-S3-Korvo-2 V3.0 and will also provide more in-depth information.

The ESP32-S3-Korvo-2 is a multimedia development board based on the ESP32-S3 chip. It is equipped with a two-microphone array which is suitable for voice recognition and near/far-field voice wake-up applications. The board integrates multiple peripherals such as LCD, camera, and microSD card. It also supports JPEG video stream processing. With all of its outstanding features, the board is an ideal choice for the development of low-cost and low-power network-connected audio and video products.

This board mainly consists of the following parts:

- Main board: ESP32-S3-Korvo-2
- LCD extension board: *ESP32-S3-Korvo-2-LCD*
- Camera

This document is mostly dedicated to the main board. For detailed information on other parts, click the links above.

The document consists of the following 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.
- *Hardware Revision Details*: Hardware revision history, known issues, and links to user guides for previous versions (if any) of the board.
- *Related Documents*: Links to related documentation.

### Getting Started

This section provides a brief introduction of ESP32-S3-Korvo-2 V3.0, instructions on how to do the initial hardware setup and how to flash firmware onto it.


Fig. 31: ESP32-S3-Korvo-2 V3.0 with ESP32-S3-WROOM-1 module

### Description of Components

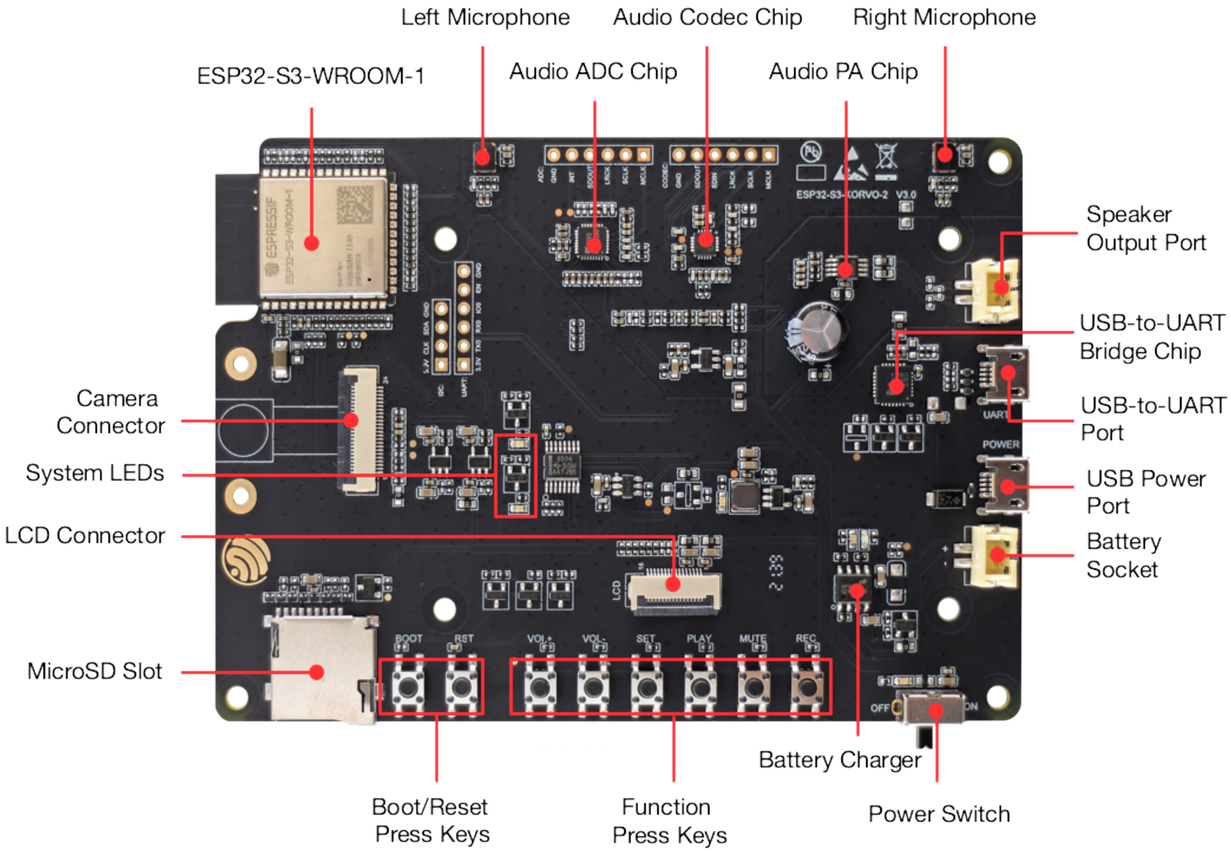


Fig. 32: ESP32-S3-Korvo-2 V3.0 (click to enlarge)

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

| Key Component | Description |
|---|---|
| ESP32-S3-WROOM-1 Module | The ESP32-S3-WROOM-1 is a powerful, generic Wi-Fi + Bluetooth LE MCU module that is built around the ESP32-S3 series of SoCs. On top of a rich set of peripherals, the acceleration for neural network computing and signal processing workloads provided by the SoC make the modules an ideal choice for a wide variety of application scenarios related to AI and Artificial Intelligence of Things (AIoT), such as wake word detection, speech commands recognition, face detection and recognition, smart home, smart appliances, smart control panel, smart speaker, etc. |
| Left Microphone | Onboard microphone connected to ADC. |
| Audio ADC Chip | ES7210 is a high-performance, low-power 4-channel audio analog-to-digital converter for microphone array applications. It is very suitable for music and speech applications. In addition, ES7210 can also be used to collect acoustic echo cancellation (AEC) echo reference signals. |
| Audio Codec Chip | The audio codec chip, ES8311, is a low-power mono audio codec. It consists of 1-channel ADC, 1-channel DAC, low noise pre-amplifier, headphone driver, digital sound effects, analog mixing, and gain functions. It is interfaced with ESP32-S3-WROOM-1 module over I2S and I2C buses to provide audio processing in hardware independently from the audio application. |
| Audio PA Chip | NS4150 is an EMI, 3 W mono Class D audio power amplifier, amplifying audio signals from audio codec chips to drive speakers. |
| Right Microphone | Onboard microphone connected to ADC. |
| Speaker Output Port | Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm/0.08" pitch. |
| USB-to-UART Bridge Chip | A single chip USB-UART bridge CP2102N provides up to 3 Mbps transfer rates for software download and debugging. |
| USB-to-UART Port | Functions as the communication interface between a PC and the ESP32-S3-WROOM-1 module. |
| USB Power Port | Provides power to the board. It is recommended to use at least 5V/2A power adapter to ensure a stable power supply. |
| Battery Socket | Two pins socket to connect a single cell Li-ion battery. |
| Power Switch | Power on/off knob: toggling it down powers the board on; toggling it up powers the board off. |
| Battery Charger | AP5056 is a constant current and constant voltage linear charger for single cell lithium-ion batteries. Used for charging of a battery connected to the Battery Socket over the Micro USB Port. |
| Function Press Keys | Six press keys labeled REC, MUTE, PLAY, SET, VOL- and VOL+. They are routed to ESP32-S3-WROOM-1 module and intended for development and testing of a UI for audio applications using a dedicated API. |
| Boot/Reset Press Keys | Boot: holding down the Boot key and momentarily pressing the Reset key initiates the firmware upload mode. Then you can upload firmware through the serial port.<br>Reset: pressing this button alone resets the system. |
| MicroSD Slot | The development board supports a microSD card in 1-bit mode, and can store or play audio files in the microSD card. |
| LCD Connector | A FPC connector with 0.5 mm pitch to connect to the LCD extension board. |
| System LEDs | Two general-purpose LEDs (green and red) controlled by ESP32-S3-WROOM-1 module to indicate certain operation states of the audio application using dedicated API. |
| Camera Connector | An external camera module that can be connected to the development board with the connector to transmit images. |

### 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 ESP32-S3-Korvo-2 V3.0
- 1 x Speaker
- 2 x USB 2.0 cable (Standard-A to Micro-B)
- 1 x 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.

#### Optional Hardware

- 1 x MicroSD card
- 1 x Li-ion battery

**Note:** Be sure to use a Li-ion battery that has a built-in protection circuit.

#### Hardware Setup

1. Connect the speaker to the **Speaker Output**.
2. Plug in the USB cables to the PC and to both USB ports of the board.
3. The standby LED (green) should turn on. Assuming that a battery is not connected, the charging LED (red) will blink every couple of seconds.
4. Toggle the **Power Switch**.
5. The red Power On LED should turn on.

#### Software Setup

Please proceed to *Get Started*, where Section *Installation Step by Step* will quickly help you set up the development environment and then flash an application example onto your board.

### Contents and Packaging

The main board and its accessories can be ordered separately. The accessories include:

- LCD extension board: ESP32-S3-Korvo-2-LCD
- Camera
- Connectors:
  - 20-pin FPC cable
- Fasteners:
  - Copper standoffs (x8)
  - Screws (x4)

### Retail Orders

If you order a few samples, each board 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/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.

### Hardware Reference

### Block Diagram

The block diagram below shows the components of ESP32-S3-Korvo-2 V3.0 and their interconnections.

### Notes on Power Distribution

### Power Supply over USB and from Battery

The main power supply is 5 V and provided by a USB. The secondary power supply is 3.7 V and provided by an optional battery. The USB power itself is fed with a dedicated cable, separating from a USB cable used for an application upload. To further reduce noise from the USB, the battery may be used instead of the USB.

As shown in the figure below, if the USB power supply and battery power supply are connected at the same time with a high VBUS, an off-state Q14, and an automatic cut-off VBAT, the USB becomes the power supply for the system.

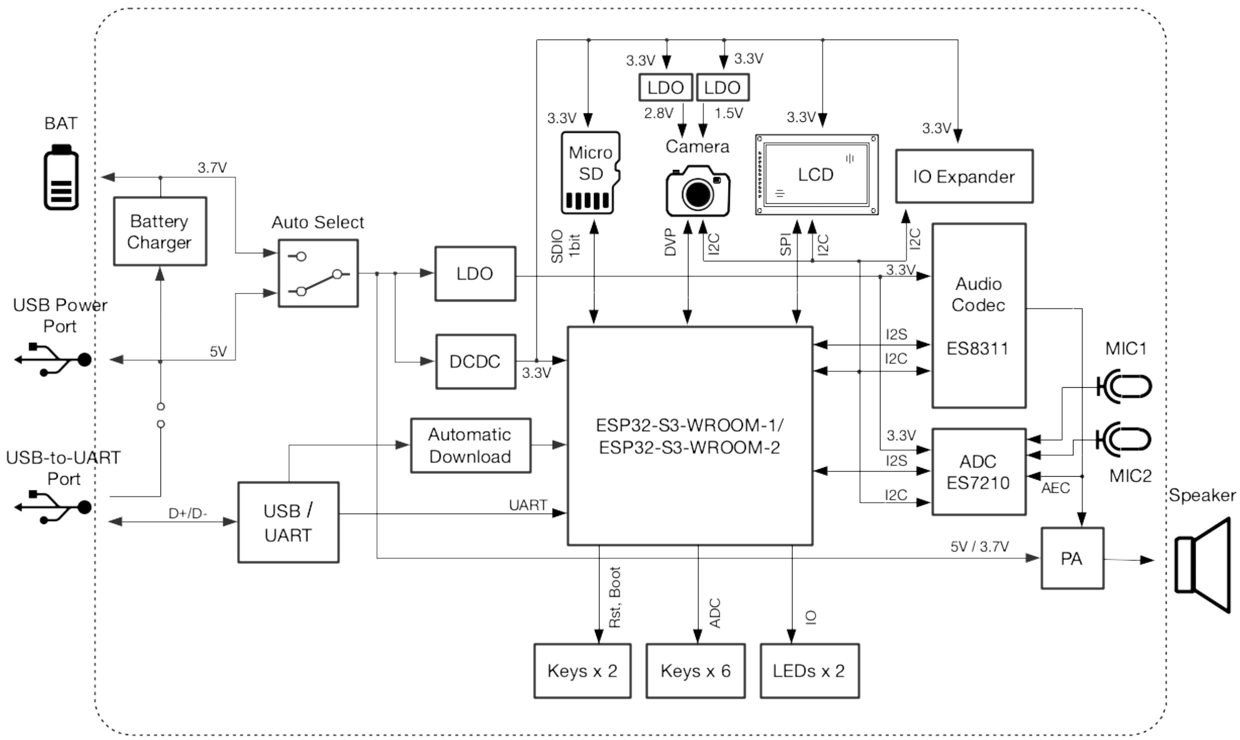


Fig. 33: ESP32-S3-Korvo-2 V3.0 Electrical Block Diagram

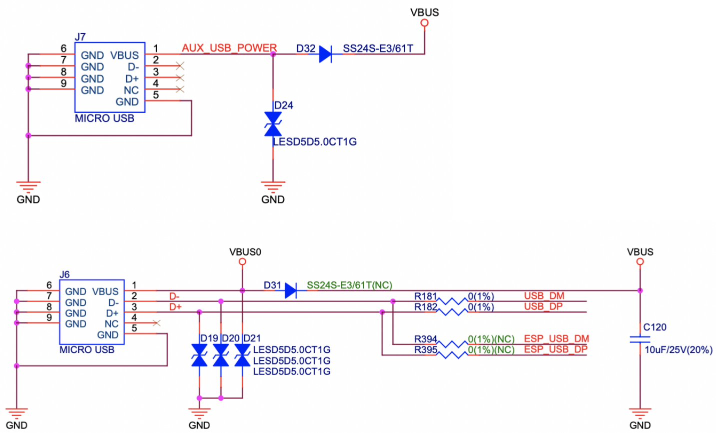


Fig. 34: ESP32-S3-Korvo-2 V3.0 - Dedicated USB Power Supply Socket

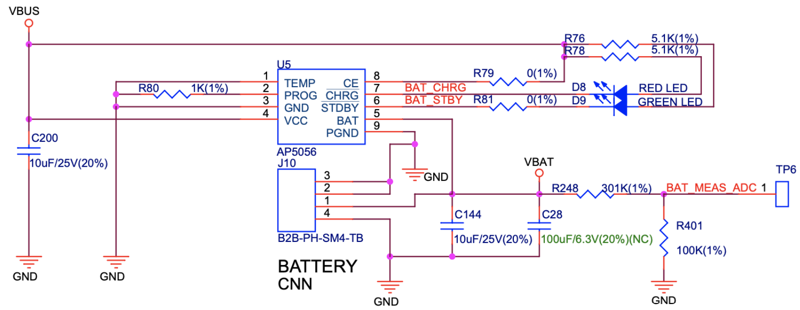


Fig. 35: ESP32-S3-Korvo-2 V3.0 - Power Supply from a Battery

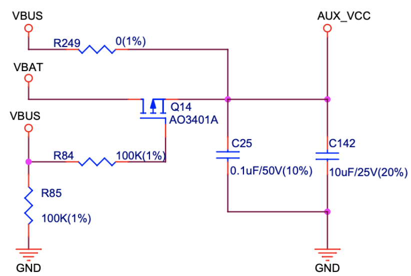


Fig. 36: ESP32-S3-Korvo-2 V3.0 - Power Supply Options

## Independent Audio and Digital Power Supply

ESP32-S3-Korvo-2 V3.0 features independent power supplies to the audio components and ESP module. This should reduce noise in the audio signal from digital components and improve overall performance of the components.

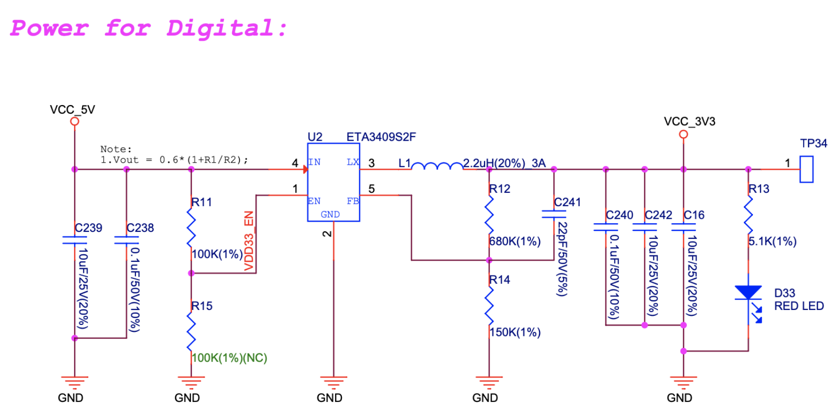


Fig. 37: ESP32-S3-Korvo-2 V3.0 - Digital Power Supply

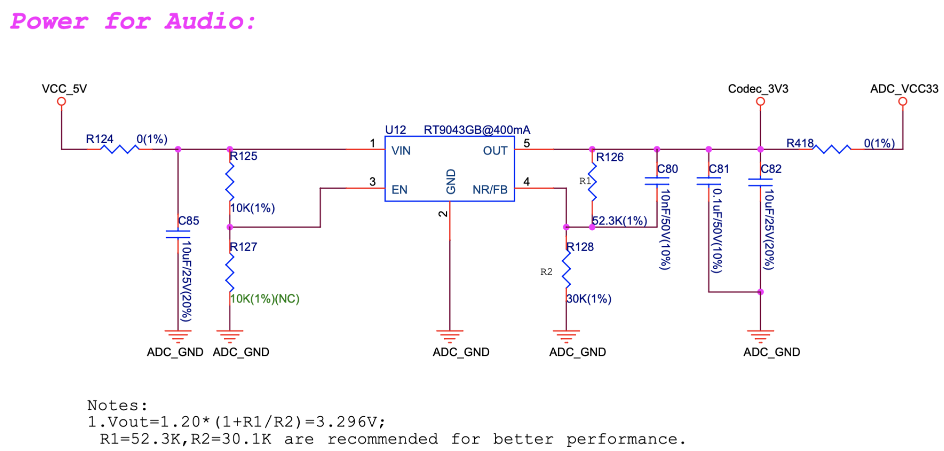


Fig. 38: ESP32-S3-Korvo-2 V3.0 - Audio Power Supply

## GPIO Allocation Summary

The table below provides allocation of GPIOs exposed on terminals of ESP32-S3-WROOM-1 module to control specific components or functions of the board.

Table 2: ESP32-S3-WROOM-1 GPIO Allocation

| Pin[1] | Pin Name | ES8311 | ES7210 | Camera | LCD | Keys | MicroSD | IO Expander | Other |
|---|---|---|---|---|---|---|---|---|---|
| 3 | EN | | | | | EN_KEY | | | |
| 4 | IO4 | | | | | | DATA0 | | |
| 5 | IO5 | | | | | REC, MUTE, PLAY, SET, VOL-, VOL+ | | | |
| 6 | IO6 | | | | | | | | BAT_MEAS_ADC |
| 7 | IO7 | | | | | | CMD | | |
| 8 | IO15 | | | | | | CLK | | |
| 9 | IO16 | I2S0_MCLK | MCLK | | | | | | |
| 10 | IO17 | I2C_SDA | I2C_SDA | SIOD | TP_I2C_SDA | | | I2C_SDA | |
| 11 | IO18 | I2C_CLK | I2C_CLK | SIOC | TP_I2C_CLK | | | I2C_CLK | |
| 12 | IO8 | I2S0_DSDIN | | | | | | | |
| 13 | IO19 | | | | | | | | ESP_USB_DM (Reserve) |
| 14 | IO20 | | | | | | | | ESP_USB_DP (Reserve) |
| 15 | IO3 | | | D5 | | | | | |
| 16 | IO46 | | | | | | | | NC |
| 17 | IO9 | I2S0_SCLK | SCLK | | | | | | |
| 18 | IO10 | | SDOUT | | | | | | |

Continued on next page

Table 2 – continued from previous page

| Pin[1] | Pin Name | ES8311 | ES7210 | Camera | LCD | Keys | MicroSD | IO Expander | Other |
|---|---|---|---|---|---|---|---|---|---|
| 19 | IO11 | | | PCLK | | | | | |
| 20 | IO12 | | | D6 | | | | | |
| 21 | IO13 | | | D2 | | | | | |
| 22 | IO14 | | | D4 | | | | | |
| 23 | IO21 | | | VSYNC | | | | | |
| 24 | IO47 | | | D3 | | | | | |
| 25 | IO48 | | | | | | | | PA_CTRL |
| 26 | IO45 | I2S0_LRCK | LRCK | | | | | | |
| 27 | IO0 | | | | LCD_SPI_SDA | BOOT_KEY | | | |
| 28 | IO35 | | | | | | | | NC |
| 29 | IO36 | | | | | | | | NC |
| 30 | IO37 | | | | | | | | NC |
| 31 | IO38 | | | HREF | | | | | |
| 32 | IO39 | | | D9 | | | | | |
| 33 | IO40 | | | XCLK | | | | | |
| 34 | IO41 | | | D8 | | | | | |
| 35 | IO42 | | | D7 | | | | | |
| 36 | RXD0 | | | | | | | | ESP0_UART0_RX |
| 37 | TXD0 | | | | | | | | ESP0_UART0_TX |
| 38 | IO2 | | | | LCD_SPI_DC | | | | |
| 39 | IO1 | | | | LCD_SPI_CLK | | | | |
| 41 | EPAD | | | | | | | | |

The GPIOs allocated to the IO expander are further expanded to multiple GPIOs.

Table 3: IO Expander GPIO Allocation

| IO Expander Pin | Pin Name | LCD | Other |
|---|---|---|---|
| 4 | P0 | | PA_CTRL |
| 5 | P1 | LCD_CTRL | |
| 6 | P2 | LCD_RST | |
| 7 | P3 | LCD_CS | |
| 9 | P4 | TP_INT | |
| 10 | P5 | | PERI_PWR_ON |
| 11 | P6 | | LED1 |
| 12 | P7 | | LED2 |

[1] Pin - ESP32-S3-WROOM-1 module pin number, GND and power supply pins are not listed.

### Connector

#### Camera Connector

| No. | Camera Signal | ESP32-S3 Pin |
|---|---|---|
| 1 | SIOD | GPIO17 |
| 2 | SIOC | GPIO18 |
| 3 | D5 | GPIO3 |
| 4 | PCLK | GPIO11 |
| 5 | D6 | GPIO12 |
| 6 | D2 | GPIO13 |
| 7 | D4 | GPIO14 |
| 8 | VSYNC | GPIO21 |
| 9 | D3 | GPIO47 |
| 10 | HREF | GPIO38 |
| 11 | D9 | GPIO39 |
| 12 | XCLK | GPIO40 |
| 13 | D8 | GPIO41 |
| 14 | D7 | GPIO42 |

#### LCD Connector

| No. | LCD Signal | ESP32-S3 Pin |
|---|---|---|
| 1 | TP_I2C_SDA | GPIO17 |
| 2 | TP_I2C_CLK | GPIO18 |
| 3 | LCD_SPI_SDA | GPIO0 |
| 4 | LCD_SPI_DC | GPIO2 |
| 5 | LCD_SPI_CLK | GPIO1 |

| No. | LCD Signal | IO Expander |
|---|---|---|
| 1 | ESP_LCD_CTRL | P1 |
| 2 | ESP_LCD_RST | P2 |
| 3 | ESP_LCD_CS | P3 |
| 4 | ESP_TP_INT | P4 |

### AEC Path

AEC path provides reference signals for AEC algorithm.

ESP32-S3-Korvo-2 provides two compatible echo reference signal source designs. One is Codec (ES8311) DAC output (DAC_AOUTLN/DAC_AOUTLP), the other is PA (NS4150) output (PA_OUTL+/PA_OUTL-). The former is the default and recommended selection. Resistors R132 and R140 marked NC (no component) in the figure below should not be installed.

The echo reference signal is collected by ADC_MIC3P/ADC_MIC3N of ADC (ES7210) and then sent back to ESP32-S3 for AEC algorithm.

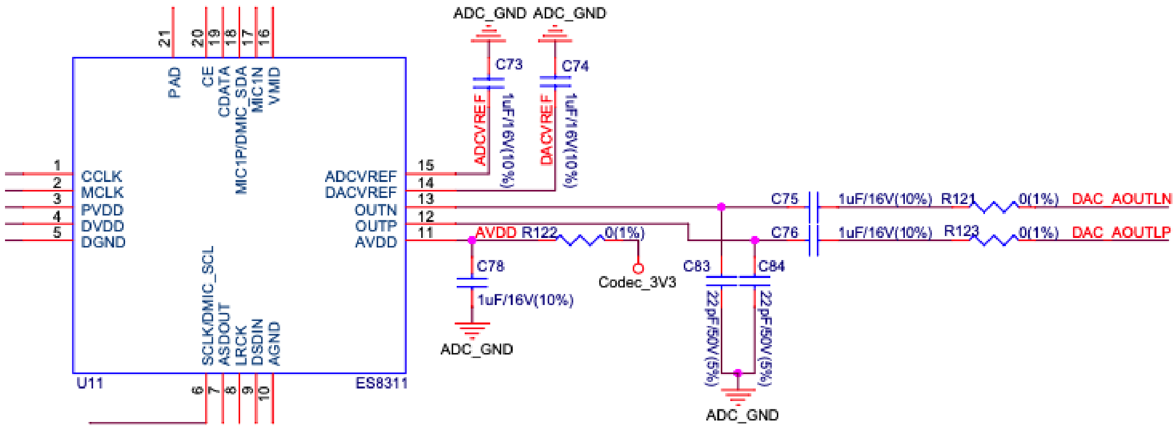


Fig. 39: ESP32-S3-Korvo-2 V3.0 - AEC Codec DAC Output (click to enlarge)

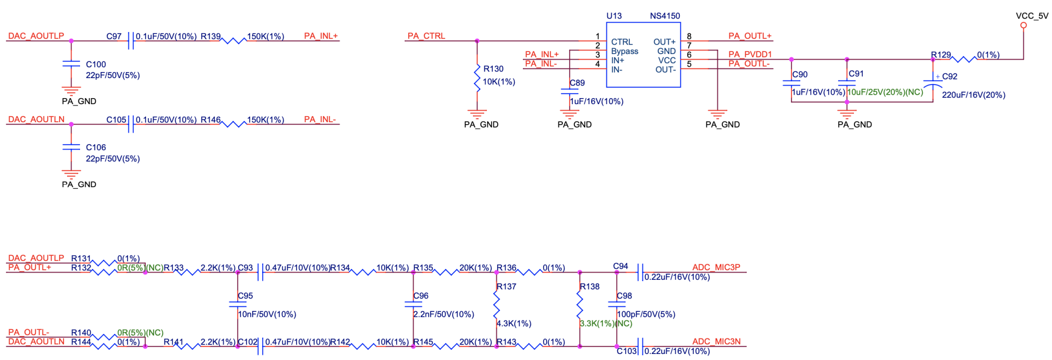


Fig. 40: ESP32-S3-Korvo-2 V3.0 - AEC PA Output (click to enlarge)

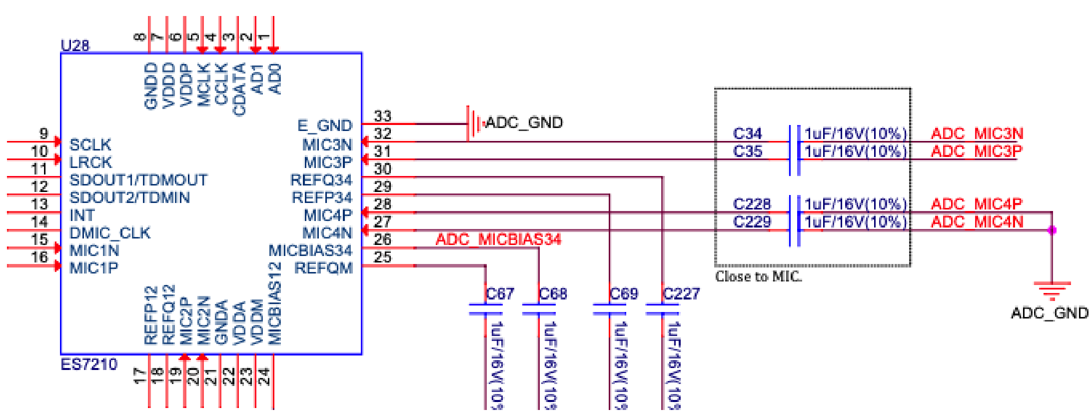


Fig. 41: ESP32-S3-Korvo-2 V3.0 - AEC Reference Signal Collection (click to enlarge)

### Hardware Setup Options

#### Using Automatic Upload

Entering of the ESP board into upload mode may be done in two ways:

- Manually by pressing both Boot and RST keys and then releasing first RST and then Boot key.
- Automatically by software performing the upload. The software is using DTR and RTS signals of the serial interface to control states of EN and IO0 of the ESP board. For details see ESP32-S3-Korvo-2 V3.0 Schematic (PDF).

#### Allocation of ESP Pins to Test Points

This section describes the allocation of test points available on the ESP32-S3-Korvo-2 V3.0 board.

The test points are bare through hole solder pads and have a standard 2.54 mm/0.1" pitch. You may need to populate them with pin headers or sockets for easy connection of external hardware.

#### Codec Test Point/J15

| No. | Codec Pin | ESP32-S3 Pin |
|---|---|---|
| 1 | MCLK | GPIO16 |
| 2 | SCLK | GPIO9 |
| 3 | LRCK | GPIO45 |
| 4 | DSDIN | GPIO8 |
| 5 | ASDOUT | – |
| 6 | GND | – |

#### ADC Test Point/J16

| No. | ADC Pin | ESP32-S3 Pin |
|---|---|---|
| 1 | MCLK | GPIO16 |
| 2 | SCLK | GPIO9 |
| 3 | LRCK | GPIO45 |
| 4 | SDOUT | GPIO10 |
| 5 | INT | – |
| 6 | GND | – |

#### UART Test Point/J17

| No. | UART Pin |
|---|---|
| 1 | 3.3V |
| 2 | TXD |
| 3 | RXD |
| 4 | IO0 |
| 5 | EN |
| 6 | GND |

#### I2C Test Point/J18

| No. | I2C Pin | ESP32-S3 Pin |
|---|---|---|
| 1 | 3.3V | – |
| 2 | CLK | GPIO18 |
| 3 | SDA | GPIO17 |
| 4 | GND | – |

#### Hardware Revision Details

This is the first revision of this board released.

#### Related Documents

- ESP32-S3 Series Datasheet (PDF)
- ESP32-S3-WROOM-1/1U Datasheet (PDF)
- ESP32-S3-Korvo-2 V3.0 Schematic (PDF)
- ESP32-S3-Korvo-2 V3.0 PCB Layout (PDF)

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

### 3.4.10 ESP32-S3-Korvo-2-LCD V1.0

[]

This user guide will help you get started with the ESP32-S3-Korvo-2-LCD extension board and will also provide more in-depth information.

This extension board cannot be bought separately and is sold as part of the *ESP32-S3-Korvo-2 V3.0 accessories*.

ESP32-S3-Korvo-2-LCD extends the functionality of ESP32-S3-Korvo-2 V3.0 (referred to as *main board* below) by adding an LCD graphic display and capacitive touchpad.

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.

#### Getting Started

This extension board adds a 2.4" LCD graphic display with the resolution of 320x240 and a 10-point capacitive touchpad. This display is connected to ESP32-S3 over the SPI bus.

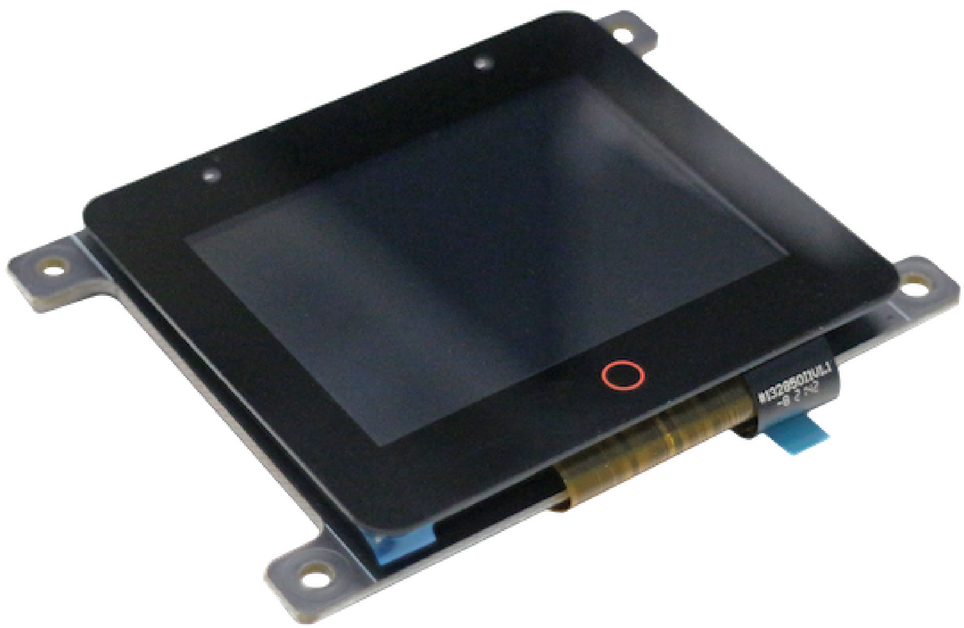

Fig. 42: ESP32-S3-Korvo-2-LCD V1.0

### Description of Components

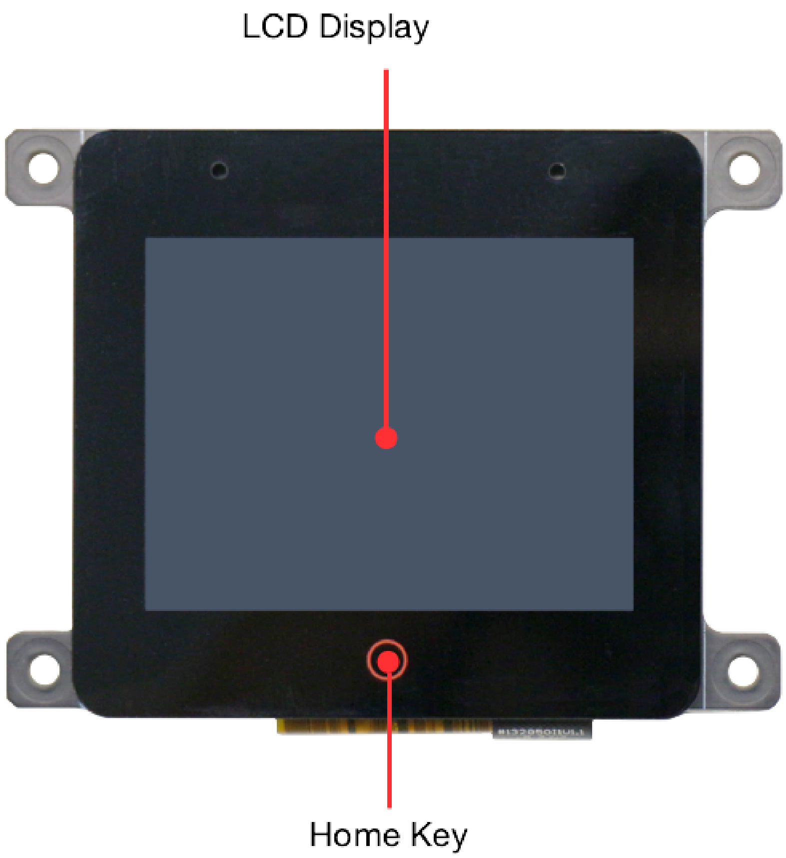


Fig. 43: ESP32-S3-Korvo-2-LCD V1.0 - front

The key components of the board are described in a clockwise direction. **Reserved** means that the functionality is available, but the current version of the board does not use it.

| Key Component | Description |
|---|---|
| LCD Display | A 2.4” 320x240 SPI LCD display module; the display driver/controller is Ilitek ILI934. |
| Home Key | (Reserved) Returns to homepage or previous page. |
| Signal Connector | Connects the power, ground, and signal wires between the extension board and the main board with a FPC cable. |
| LCD Connector | Connects LCD display to the driver circuit of this board. |
| TP Connector | Connects LCD display to the touch circuit of this board. |

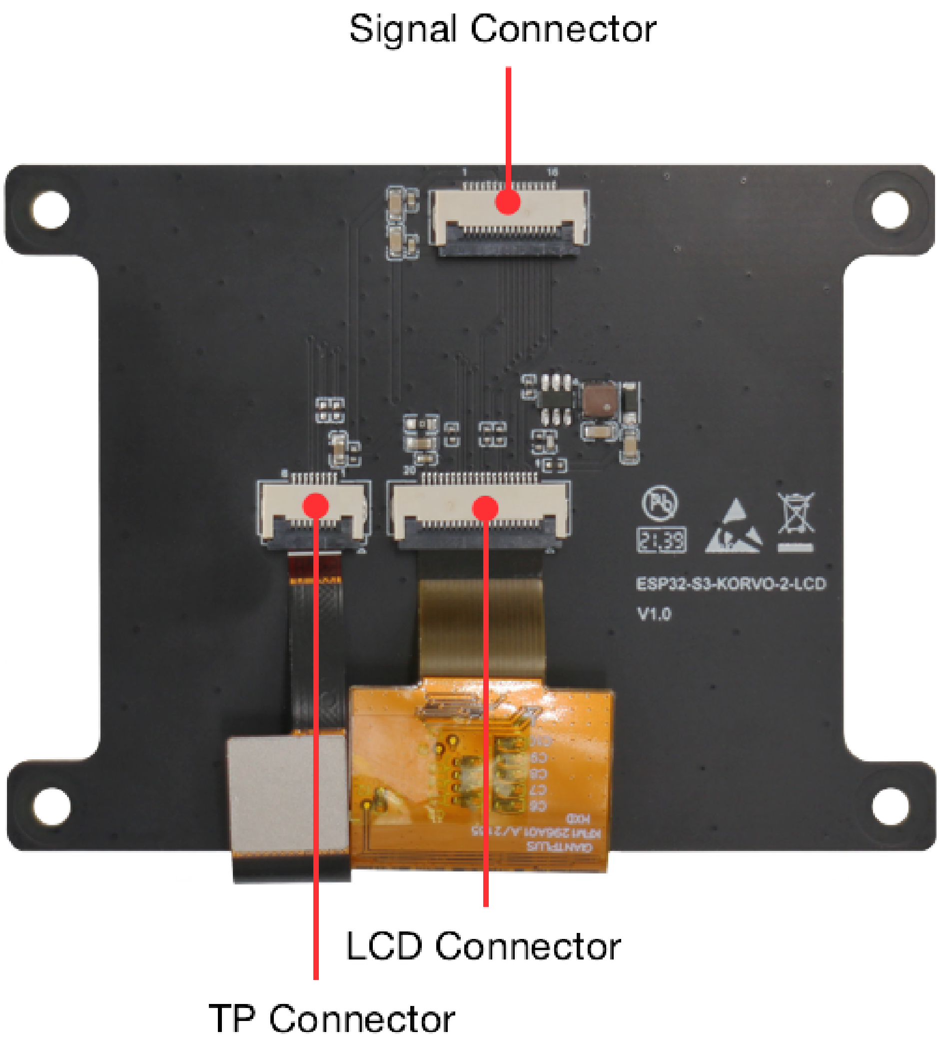


Fig. 44: ESP32-S3-Korvo-2-LCD V1.0 - back

### 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

- Main board: ESP32-S3-Korvo-2 V3.0
- Extension board: ESP32-S3-Korvo-2-LCD V1.0
- Two USB 2.0 cables (Standard-A to Micro-B)
- Mounting copper standoffs and screws (for stable mounting)
- A FPC cable (for connecting the main board and extension board)
- Computer running Windows, Linux, or macOS

#### Hardware Setup

To mount your ESP32-S3-Korvo-2-LCD onto ESP32-S3-Korvo-2:

1. Connect the two boards with the FPC cable.
2. Install copper standoffs and screws for stable mounting.

#### Software Setup

See Section *Software Setup* of the main board user guide.

### Hardware Reference

#### Block Diagram

The block diagram below shows the components of ESP32-S3-Korvo-2-LCD and their interconnections.

### Hardware Revision Details

Initial release.

### Related Documents

- *ESP32-S3-Korvo-2 V3.0*
- ESP32-S3-Korvo-2-LCD Schematic (PDF)
- ESP32-S3-Korvo-2-LCD PCB layout (PDF)

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

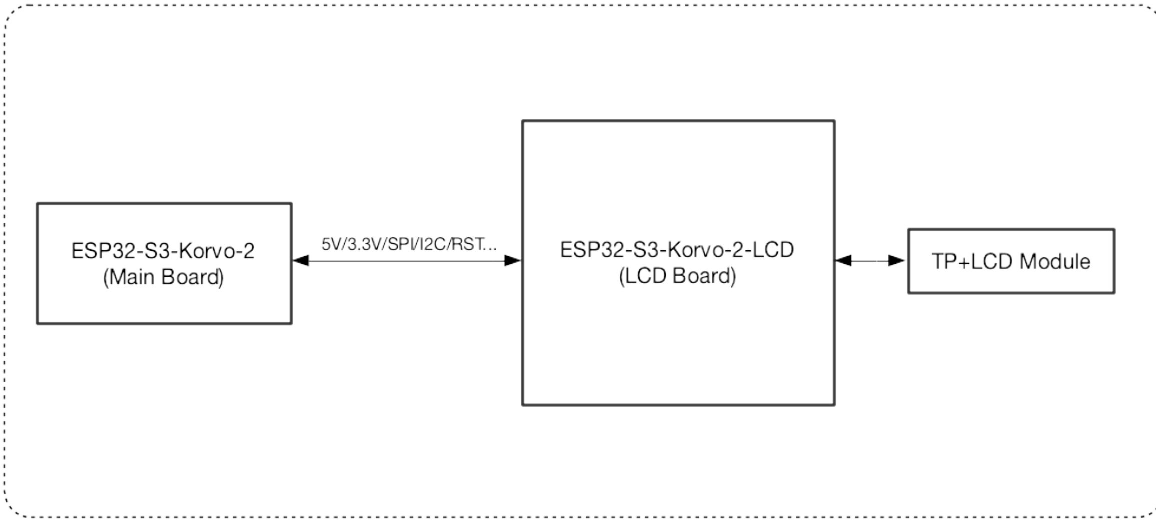


Fig. 45: ESP32-S3-Korvo-2-LCD

### 3.4.11 ESP32-C3-Lyra V2.0

[]

This user guide will help you get started with ESP32-C3-Lyra V2.0 and will also provide more in-depth information.

The document consists of the following sections:

- *Board Overview*: Overview of the board hardware/software.
- *Start Application Development*: How to set up hardware/software to develop applications.
- *Hardware Reference*: More detailed information about the board's hardware.
- *Hardware Revision Details*: Hardware revision history, known issues, and links to user guides for previous versions (if any) of the board.
- *Ordering*: How to buy the board.
- *Related Documents*: Links to related documentation.

#### Board Overview

ESP32-C3-Lyra is an ESP32-C3-based audio development board produced by Espressif for controlling light with audio. The board has control over the microphone, speaker, and LED strip, perfectly matching customers' product development needs for ultra-low-cost and high-performance audio broadcasters and rhythm light strips.

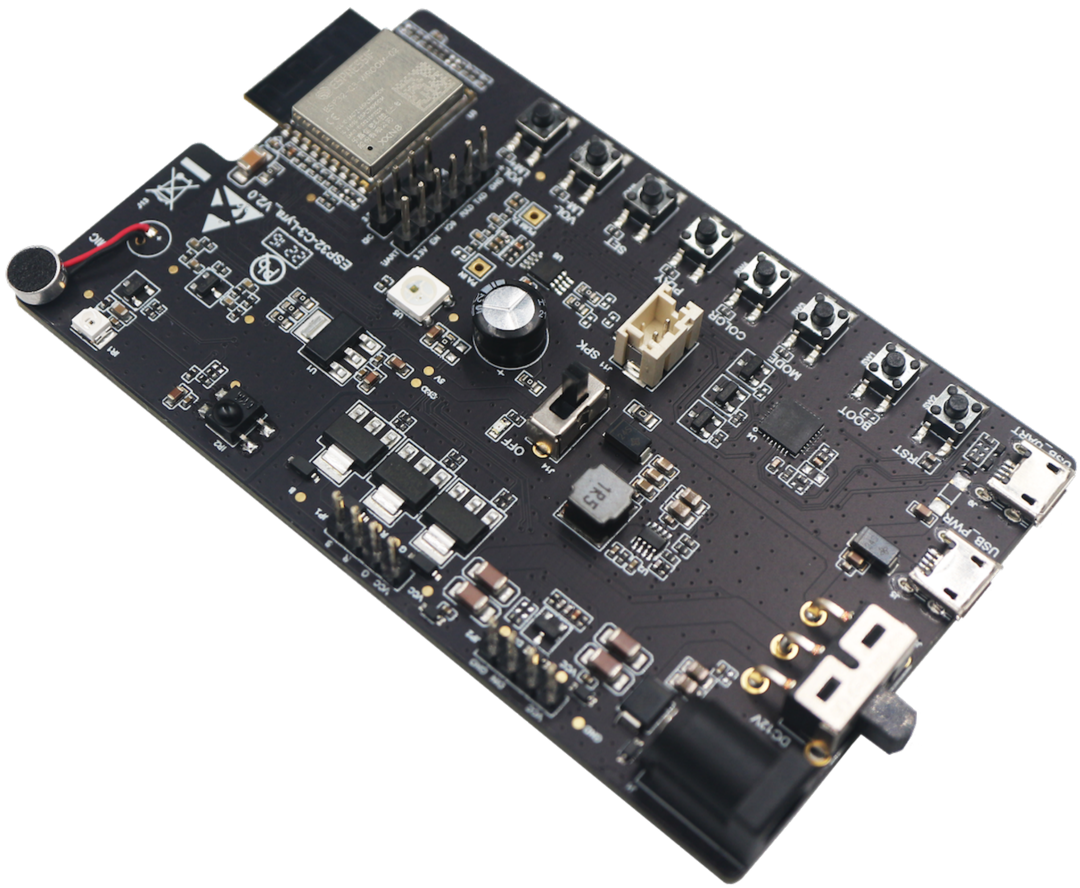

Fig. 46: ESP32-C3-Lyra with ESP32-C3-WROOM-02 module

### Feature List

The main features of the board are listed below:

- **Module Embedded:** ESP32-C3-WROOM-02 module with a 4 MB external SPI flash
- **Audio:** built-in ECM microphone, speaker power amplifier, speaker connector
- **LED Strip Connector:** support for two types of connections, i.e., connections to addressable LED strips and RGB LED strips
- **Infrared Control:** support for infrared (IR) transmitting and receiving
- **Keys:** boot key, reset key, and six function keys (MODE, COLOR, PLAY/PAUSE, SET, VOL+/LM+, VOL-/LM-)
- **USB:** 1 x USB Power Port, 1 x USB-to-UART Port
- **Power Supply:** 5 V power supply over USB or 12 V DC power supply

### Block Diagram

The block diagram below shows the components of ESP32-C3-Lyra and their interconnections.

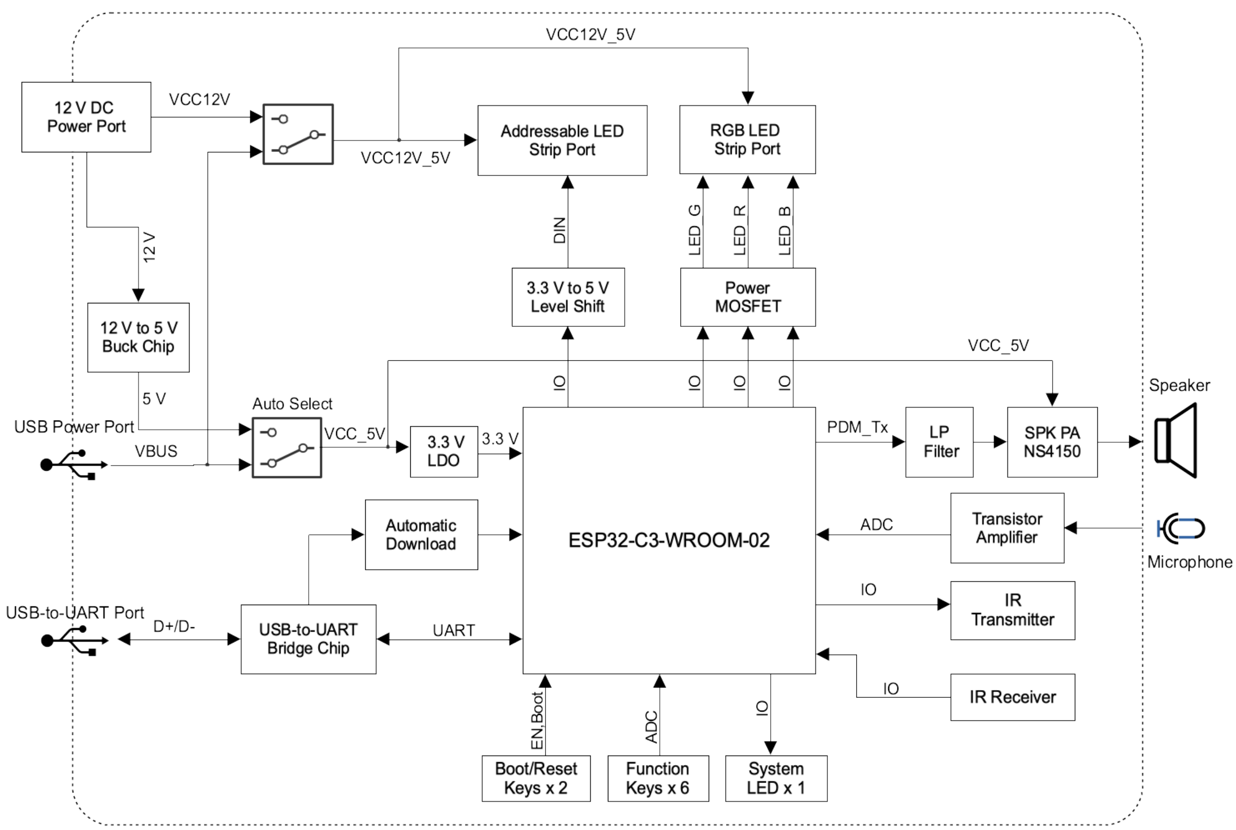


Fig. 47: ESP32-C3-Lyra Block Diagram (click to enlarge)

### Description of Components

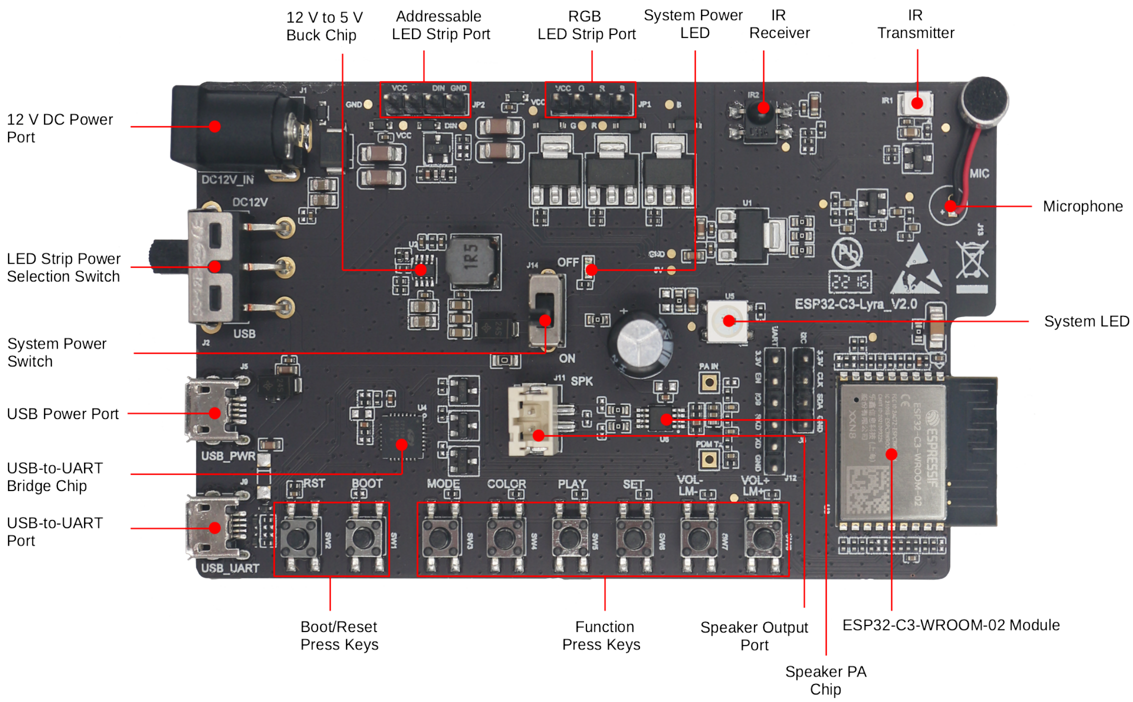


Fig. 48: ESP32-C3-Lyra - front (click to enlarge)

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

| Key Component | Description |
|---|---|
| ESP32-C3-WROOM-02 Module | It is a general-purpose Wi-Fi and Bluetooth LE module developed based on ESP32-C3, a 32-bit RISC-V single-core processor that operates at up to 160 MHz. The module has a rich set of peripherals and a high performance, making it an ideal choice for smart homes, industrial automation, health care, consumer electronics, etc. It integrates a 4 MB external SPI flash and an on-board PCB antenna. The ESP32-C3-WROOM-02U module is also compatible with this board, but it needs to connect to an external antenna. |
| Speaker PA Chip | NS4150 is an EMI, 3 W mono Class D audio power amplifier, amplifying audio signals from ESP32-C3 PDM_TX to drive speakers. |
| Speaker Output Port | Output socket to connect a speaker. The 4-ohm and 3-watt speaker is recommended. The pins have a 2.00 mm/0.08" pitch. |
| Function Press Keys | Six function press keys, including MODE, COLOR, PLAY/PAUSE, SET, VOL+/LM+, VOL-/LM-. They are routed to the **ESP32-C3-WROOM-02 Module** and intended for the development and testing of a UI for audio applications or LED strips using dedicated APIs. |
| Boot/Reset Press Keys | Boot: holding down the Boot key and momentarily pressing the Reset button initiates the firmware upload mode. Then you can upload firmware through the serial port. Reset: pressing this key alone resets the system. |
| USB-to-UART Port | Functions as the communication interface between the PC and the ESP32-C3-WROOM-02 module. |
| USB-to-UART Bridge Chip | The single-chip USB-UART bridge CP2102N provides up to 3 Mbps transfer rates for software download and debugging. |
| USB Power Port | Provides power to the board. It is recommended to use at least 5 V/2 A power adapters to ensure a stable power supply. |
| System Power Switch | System Power on/off knob. Toggling it to **ON** turns the 5 V system power on; toggling it to **OFF** turns the 5 V system power off. |
| LED Strip Power Selection Switch | Toggle this switch to select between a 5 V power supply over USB and a 12 V DC power supply for your LED strip according to the working voltage of the LED strip and the type of the power adapter you actually use. |
| 12 V DC Power Port | Supports 12 V DC power adapters with a maximum current of 2 A. The DC power Jack contact have an outer diameter of 5.5 mm and an inner contact diameter of 2.5 mm. |
| 12 V to 5 V Buck Chip | The 12 V to 5 V buck chip MP2313 is a high-efficiency synchronous step-down converter that operates at 1 A and 2 MHz. |
| Addressable LED Strip Port | It is a male pin header connector with 4 x 1 pins and a 2.54 mm pitch. It can connect to the addressable LED strip that is controlled with a single wire. It supports 5 V and 12 V LED strips, such as WS2811 and WS2812 LED. ESP32-C3 can send commands to control the LED strips over RMT or SPI. |
| RGB LED Strip Port | It is a male pin header connector with 4 x 1 pins and a 2.54 mm pitch. It can connect to regular RGB LED strips (non-addressable, individual wire per color) that operate at 5 V or 12 V. ESP32-C3 can output PWM waveform via this port to control the LED strips. |
| System Power LED | It turns red when **System Power Switch** is toggled to ON. |
| IR Receiver | IRM-H638T/TR2 is a miniature SMD type infrared remote control system receiver. The demodulated output signal can directly be decoded by ESP32-C3. |
| IR Transmitter | IR67-21C/TR8 is an infrared emitting diode. It is spectrally matched with silicon photodiode and phototransistor. |
| Microphone | On-board ECM microphone. Signals picked up by it are amplified via transistors and sent to the analog-to-digital converter (ADC) of ESP32-C3-WROOM-02. |
| System LED | It is an RGB LED, model WS2812C, controlled by the ESP32-C3-WROOM-02 via GPIO, which can be used to indicate the operating status of the audio application. |

### Default Firmware and Function Test

Each ESP32-C3-Lyra comes with a pre-built default firmware that allows you to test its functions including LED control (LEDC), remote control transceiver (RMT), ADC, and pulse-density modulation (PDM_TX). This section describes how to test peripheral's function with the pre-built firmware.

> **Note:** The default firmware of ESP32-C3-Lyra sold in the Developing IoT Projects with ESP32-C3 Package II provides a musical rhythm light ring effect.

#### Preparing Hardware

See Section *Required Hardware* and *Optional Hardware* for more information.

- 1 x ESP32-C3-Lyra
- 2 x USB 2.0 cable (Standard-A to Micro-B)
- 1 x Computer running Windows, Linux, or macOS
- 1 x 5 V RGB LED strip WS2812 (optional)
- 1 x Mobile phone or music player
- 1 x Speaker (optional)

#### Connecting Hardware

- Before powering up your board, please make sure that it is in good condition with no obvious signs of damage.
- Connect the board to the 5 V power supply through the **USB Power Port** using a USB cable. After the board is powered up, you will notice that the **System Power LED** turns on, which means the board is powered up. If the LED is not on, please toggle the **System Power Switch**.
- Toggle the **LED Strip Power Selection Switch** to the USB power side.
- Connect the board to the computer through the **USB-to-UART Port** using a USB cable.

#### Testing Default Firmware

> **Note:** If you are developing with ESP32-C3-Lyra provided in the Developing IoT Projects with ESP32-C3 Package II, please skip this step.

1. Press the **Reset Press Key** on the board.
2. The board automatically starts the flash test. The log shown on a PC connected to **USB-to-UART Port** is as follows:

```
Step1 Flash Test Start
Step1 Flash Test OK
```

3. The board tests the **Function Press Keys**. Please press the key as the log prompts. For example, press **VOL+** when you see the following log:

```
Step2 Keys Test Start
Please press The Key: VOL+
```

4. The board tests the **System LED**. You will see the LED keep switching between red, blue, and green. Then, press the key `VOL+/LM+` to proceed to the next step.
5. The board tests LEDC (PWM). If you connect an RGB LED strip to the **RGB LED Strip Port**, you will see the LEDs breathing. Then, press the key `VOL+/LM+` to proceed to the next step.
6. The board tests ADC. If you play the 1 kHz sine audio signal close to the **Microphone** with the mobile phone or music player, the following log will be seen when the board detects the audio signal:

```
Step5 Adc Test Start
Please play 1khz audio
Step5 Adc Test OK
```

7. The board tests the PDM_TX function. Connect the speaker to the **Speaker Output Port** and you will hear the music played from flash.

### Software Support

ESP-ADF is the development framework for ESP32-C3-Lyra. To see which version of ESP-ADF is supported for this board, please go to the section Hardware.

Below are other software repositories developed by Espressif that may help you experiment with the functions of ESP32-C3-Lyra.

- ESP-IDF: development framework for Espressif SoCs based on FreeRTOS with a rich set of components, including LED control (LEDC), ADC, RMT, SPI etc.

Application examples for this board can be found at application example .

### Start Application Development

This section provides instructions on how to do hardware and software setup and flash firmware onto the board to develop your own application.

### Required Hardware

| Hardware | Qty | Note |
|---|---|---|
| ESP32-C3-Lyra | 1 | – |
| USB 2.0 cables (Standard-A to Micro-B) | 2 | One for USB power supply, the other for flashing firmware onto the board. 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. |
| Computer running Windows, Linux, or macOS | 1 | – |
| Speaker | 1 | The 4-ohm 3-watt speaker is recommended. It should be fitted with JST PH 2.0 2-Pin plugs. In case you do not have this type of plug it is also fine to use Dupont female jumper wires during development. |

### Optional Hardware

| Hardware | Qty | Note |
|---|---|---|
| 12 V DC adapter | 1 | The maximum operating current of the adapter is 2 A. It provides power supply for 12 V LED strips. |
| 5 V or 12 V addressable LED strip/ring | 1 | It is recommended to use WS2812/WS2811 LED strip (a female connector with 4 x 1 pins and a 2.54 mm pitch), or a WS2812 LED ring with 16 individually addressable RGB LEDs assembled (a female connector with 3 x 1 pins and a 2.54 mm pitch). This LED strip/ring should be connected to the **Addressable LED Strip Port** (*JP2*). |
| 5 V or 12 V RGB LED strip | 1 | It should have a female connector with 4 x 1 pins and a 2.54 mm pitch. This LED strip should be connected to **RGB LED Strip Port** (*JP1*). |

### Power Supply Options

There are two ways to provide power to the board:

- **USB Power Port** (5 V)
- **12 V DC Power Port**

### Hardware Setup

Prepare the board for loading of the first sample application:

1. Connect the speaker to the **Speaker Output Port**.
2. (Optional) Connect the LED strip to the development board through the **Addressable LED Strip Port** or the **RGB LED Port** depending on the type of your LED strip.
3. Connect the power supply to the development board through the **USB Power Port** (5 V) or the **12 V DC Power Port** accordingly to supply power for your LED strip.
4. (Optional) Toggle the **LED Strip Power Selection Switch** depending on the working voltage and current of your LED strip.

   **Note:** If you toggle the switch to the wrong side, the light strip will work abnormally. **Do not** power the 5 V LED strip with the 12 V DC adapter. Otherwise, the light strip will be damaged.

5. Toggle the **System Power Switch** to **ON**. The red **System Power LED** should turn on.
6. Connect the board to the computer through the **USB-to-UART Port** using a USB cable.

Now the board is ready for software setup.

### Software Setup

After hardware setup, you can proceed to *Get Started* to prepare development tools.

For more software information on developing applications, please go to *Software Support*.

### Hardware Reference

This section provides more detailed information about the board's hardware.

### GPIO Allocation

The table provides the allocation of GPIOs exposed on terminals of the ESP32-C3-WROOM-02 module to control specific components or functions of the board.

### Power Distribution

#### Power Supply over USB or from 12 V/2 A DC Input

There are two ways to power the development board: 5 V USB Power Port or 12 V/2 A DC input.

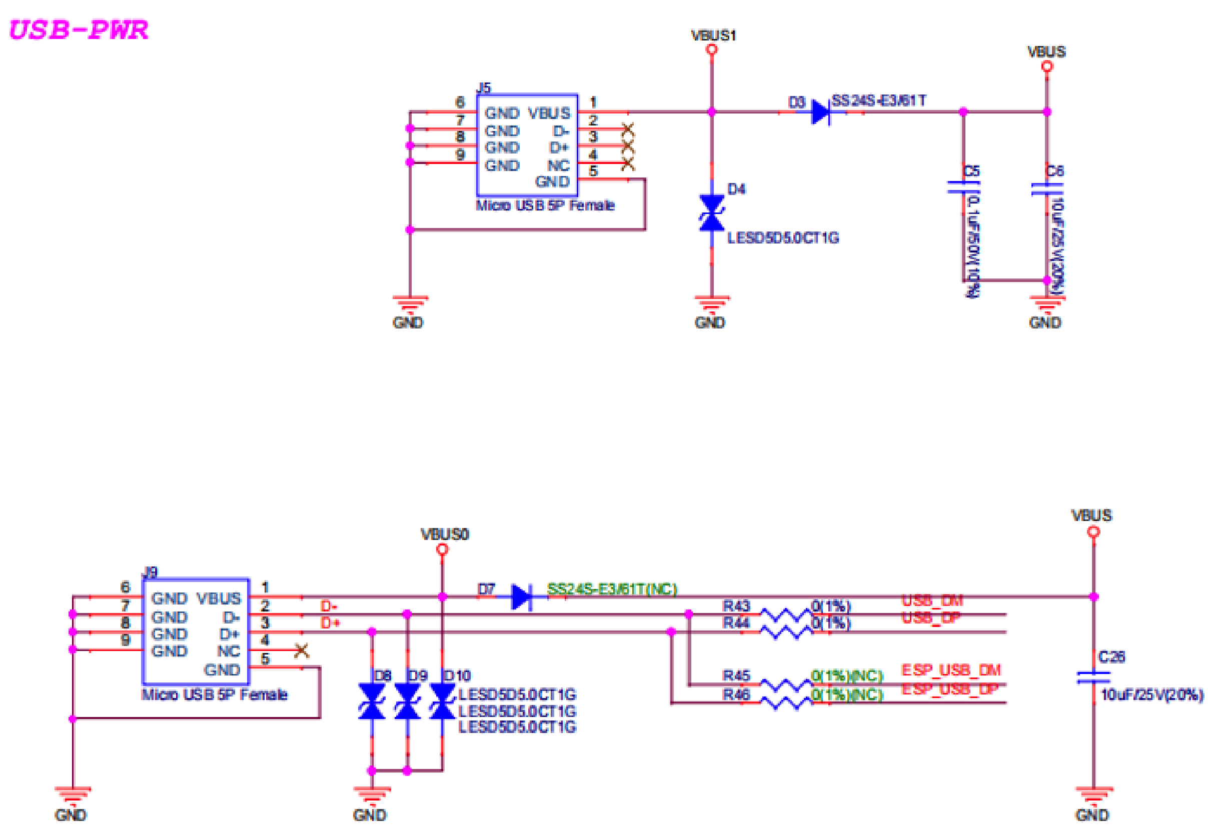


Fig. 49: ESP32-C3-Lyra - Dedicated USB Power Supply Socket

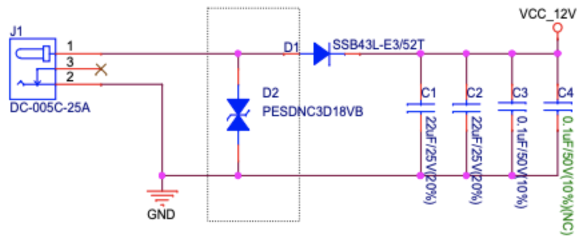


Fig. 50: ESP32-C3-Lyra - Power Supply from 12 V DC Input

### LED Strip Power Selection Switch

According to the working voltage and current of your LED strip, select a proper power adapter and the port, and toggle the **LED Strip Power Selection Switch** to the corresponding side to power up the LED strip.

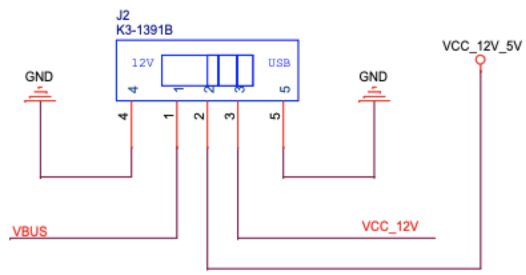


Fig. 51: LED Strip Power Selection Switch

### 12 V to 5 V Buck Power

### System 3.3 V Power

### Connector

### RGB LED Strip Connector (JP1)

| No. | Signal Name | ESP32-C3 Pin |
|---|---|---|
| 1 | VCC_12V_5V | – |
| 2 | LED_G | GPIO6 |
| 3 | LED_R | GPIO5 |
| 4 | LED_B | GPIO4 |

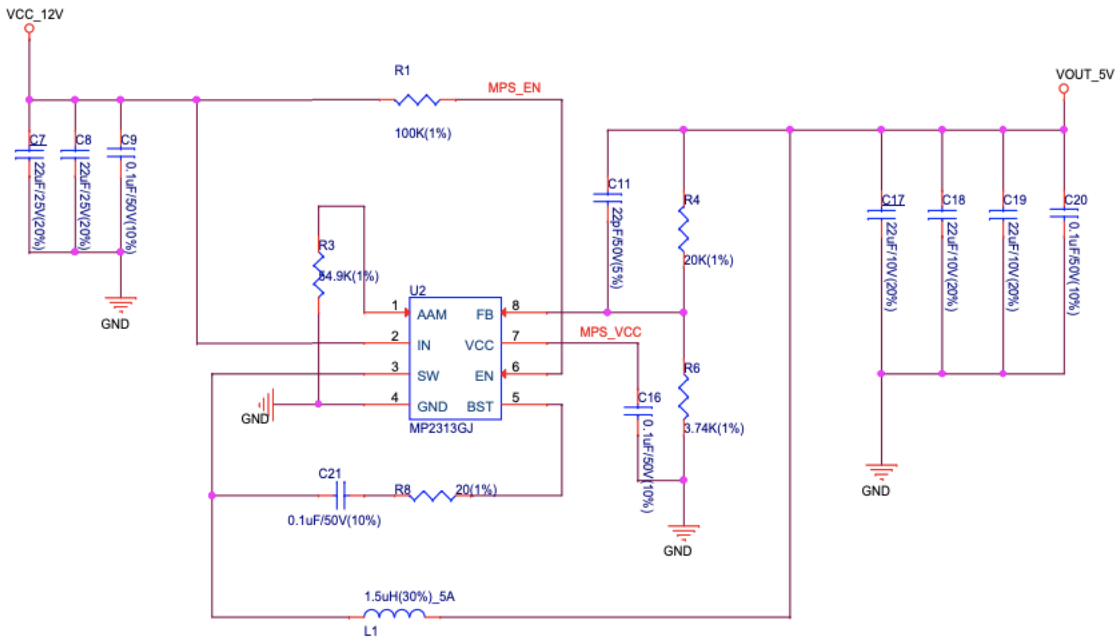


Fig. 52: 12 V to 5 V Buck Power Circuit

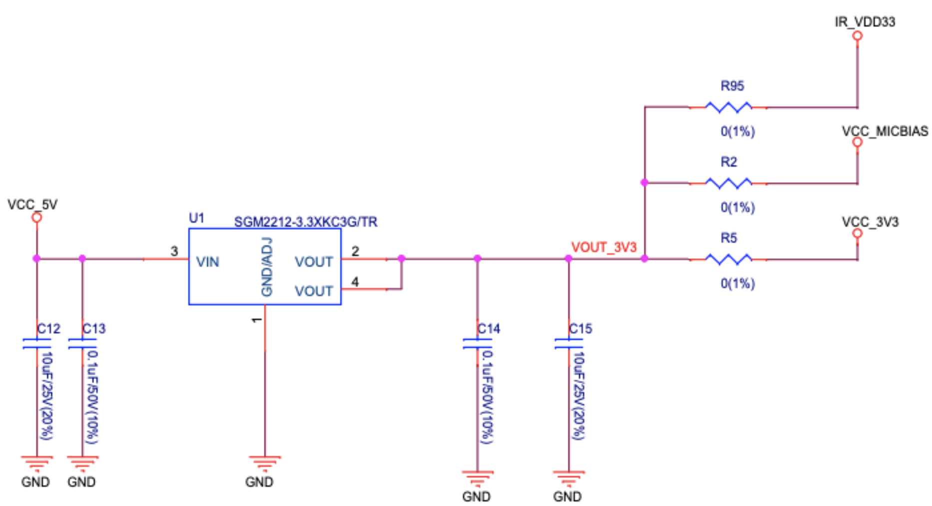


Fig. 53: System 3.3 V Power Circuit

#### Addressable LED Strip Connector (JP2)

| No. | Signal Name | ESP32-C3 Pin |
|---|---|---|
| 1 | VCC_12V_5V | – |
| 2 | DIN | GPIO7 |
| 3 | DIN | GPIO7 |
| 4 | GND | – |

#### Pinout of Extension Headers

There are several pin headers available to connect external components, check the state of particular signal bus, or debug operation of ESP32-C3. Note that some signals are shared. See Section *GPIO Allocation* for details.

#### UART Header (JP12)

| No. | Signal Name | ESP32-C3 Pin |
|---|---|---|
| 1 | VCC_3V3 | – |
| 2 | ESP_EN | EN |
| 3 | ESP_BOOT | GPIO9 |
| 4 | ESP_UART_RXD | U0RXD |
| 5 | ESP_UART_TXD | U0TXD |
| 6 | GND | – |

#### I2C Header (JP8)

| No. | Signal Name | ESP32-C3 Pin |
|---|---|---|
| 1 | VCC_3V3 | – |
| 2 | I2C_CLK | GPIO8 |
| 3 | I2C_DATA | GPIO9 |
| 4 | GND | – |

#### Hardware Revision Details

No previous revisions.

#### Ordering

If you order a few samples, each board comes in an individual package.

For retail orders, please go to the official website https://www.espressif.com/en/company/contact/buy-a-sample, or directly order in our Taobao shop https://world.taobao.com/item/677273363812.htm?spm=a21wu.12321156-tw.recommend-tpp.4.19a61924ZMaqpf.

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

#### Related Documents

- Datasheet
  - ESP32-C3 Series Datasheet (PDF)
  - ESP32-C3-WROOM-02 & ESP32-C3-WROOM-02U Datasheet (PDF)
- Schematic
  - ESP32-C3-Lyra Schematic (PDF)
- PCB Layout
  - ESP32-C3-Lyra PCB Layout (PDF)

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

## 3.5 Audio Samples

Music files in this section are intended for testing of audio applications. The files are organized into different *Formats* and *Sample Rates*.

### 3.5.1 Formats

The tables below provides an audio file converted from 'wav' format into several other audio formats.

#### Long Samples

The audio track duration in this section is 3 minutes and 7 seconds.

#### Two Channel Audio

| No | Format | Audio File | Size [kB] |
|---|---|---|---|
| 1 | aac | ff-16b-2c-44100hz.aac | 2,995 |
| 2 | ac3 | ff-16b-2c-44100hz.ac3 | 2,994 |
| 3 | aiff | ff-16b-2c-44100hz.aiff | 33,002 |
| 4 | flac | ff-16b-2c-44100hz.flac | 22,406 |
| 5 | m4a | ff-16b-2c-44100hz.m4a | 3,028 |
| 6 | mp3 | ff-16b-2c-44100hz.mp3 | 2,994 |
| 7 | mp4 | ff-16b-2c-44100hz.mp4 | 3,079 |
| 8 | ogg | ff-16b-2c-44100hz.ogg | 2,612 |
| 9 | opus | ff-16b-2c-44100hz.opus | 2,598 |
| 10 | ts | ff-16b-2c-44100hz.ts | 5,510 |
| 11 | wav | ff-16b-2c-44100hz.wav | 32,229 |
| 12 | wma | ff-16b-2c-44100hz.wma | 3,227 |

Playlist containing all above files: ff-16b-2c-playlist.m3u

### Single Channel Audio

| No | Format | Audio File | Size [kB] |
| --- | --- | --- | --- |
| 1 | aac | ff-16b-1c-44100hz.aac | 1,650 |
| 2 | ac3 | ff-16b-1c-44100hz.ac3 | 2,193 |
| 3 | aiff | ff-16b-1c-44100hz.aiff | 16,115 |
| 4 | amr | ff-16b-1c-8000hz.amr | 299 |
| 5 | flac | ff-16b-1c-44100hz.flac | 10,655 |
| 6 | m4a | ff-16b-1c-44100hz.m4a | 1,628 |
| 7 | mp3 | ff-16b-1c-44100hz.mp3 | 1,463 |
| 8 | ogg | ff-16b-1c-44100hz.ogg | 1,558 |
| 9 | opus | ff-16b-1c-44100hz.opus | 1,641 |
| 10 | wav | ff-16b-1c-44100hz.wav | 16,115 |
| 11 | wma | ff-16b-1c-44100hz.wma | 3,151 |

Playlist containing all above files: ff-16b-1c-playlist.m3u

### Short Samples

If you need shorter audio files for testing, this section provides 16 seconds audio tracks.

### Two Channel Audio

| No | Format | Audio File | Size [kB] |
| --- | --- | --- | --- |
| 1 | aac | gs-16b-2c-44100hz.aac | 241 |
| 2 | ac3 | gs-16b-2c-44100hz.ac3 | 380 |
| 3 | aiff | gs-16b-2c-44100hz.aiff | 2,792 |
| 4 | flac | gs-16b-2c-44100hz.flac | 1,336 |
| 5 | m4a | gs-16b-2c-44100hz.m4a | 258 |
| 6 | mp3 | gs-16b-2c-44100hz.mp3 | 254 |
| 7 | mp4 | gs-16b-2c-44100hz.mp4 | 259 |
| 8 | ogg | gs-16b-2c-44100hz.ogg | 229 |
| 9 | opus | gs-16b-2c-44100hz.opus | 219 |
| 10 | ts | gs-16b-2c-44100hz.ts | 286 |
| 11 | wav | gs-16b-2c-44100hz.wav | 2,792 |
| 12 | wma | gs-16b-2c-44100hz.wma | 276 |

Playlist containing all above files: gs-16b-2c-playlist.m3u

### Single Channel Audio

| No | Format | Audio File | Size [kB] |
|---|---|---|---|
| 1 | amr | gs-16b-1c-8000hz.amr | 25 |
| 2 | aac | gs-16b-1c-44100hz.aac | 137 |
| 3 | ac3 | gs-16b-1c-44100hz.ac3 | 190 |
| 4 | aiff | gs-16b-1c-44100hz.aiff | 1,397 |
| 5 | flac | gs-16b-1c-44100hz.flac | 645 |
| 6 | m4a | gs-16b-1c-44100hz.m4a | 258 |
| 7 | mp3 | gs-16b-1c-44100hz.mp3 | 127 |
| 8 | ogg | gs-16b-1c-44100hz.ogg | 144 |
| 9 | opus | gs-16b-1c-44100hz.opus | 132 |
| 10 | wav | gs-16b-1c-44100hz.wav | 1,497 |
| 11 | wma | gs-16b-1c-44100hz.wma | 276 |

Playlist containing all above files: gs-16b-1c-playlist.m3u

## 3.5.2 Sample Rates

The files in this section have been prepared by converting a single audio file into different sampling rates defined in MPEG Layer III specification. Both mono and stereo versions of files are provided. The bit depth of files is 16 bits.

| | Sample Rate | MPEG III | Channels | Bit Rate | Size |
|---|---|---|---|---|---|
| Audio File | [Hz] | ver | | [kbit/s] | [kB] |
| ff-16b-1c-8000hz.mp3 | 8000 | 2.5 | mono | 8 | 183 |
| ff-16b-1c-11025hz.mp3 | 11025 | 2.5 | mono | 16 | 366 |
| ff-16b-1c-12000hz.mp3 | 12000 | 2.5 | mono | 16 | 366 |
| ff-16b-1c-16000hz.mp3 | 16000 | 2 | mono | 24 | 548 |
| ff-16b-1c-22050hz.mp3 | 22050 | 2 | mono | 32 | 731 |
| ff-16b-1c-24000hz.mp3 | 24000 | 2 | mono | 32 | 731 |
| ff-16b-1c-32000hz.mp3 | 32000 | 1 | mono | 48 | 1,097 |
| ff-16b-1c-44100hz.mp3 | 44100 | 1 | mono | 64 | 1,462 |
| ff-16b-2c-8000hz.mp3 | 8000 | 2.5 | joint stereo | 24 | 549 |
| ff-16b-2c-11025hz.mp3 | 11025 | 2.5 | joint stereo | 32 | 731 |
| ff-16b-2c-12000hz.mp3 | 12000 | 2.5 | joint stereo | 32 | 731 |
| ff-16b-2c-16000hz.mp3 | 16000 | 2 | joint stereo | 48 | 1,097 |
| ff-16b-2c-22050hz.mp3 | 22050 | 2 | joint stereo | 64 | 1,462 |
| ff-16b-2c-24000hz.mp3 | 24000 | 2 | joint stereo | 64 | 1,462 |
| ff-16b-2c-32000hz.mp3 | 32000 | 1 | joint stereo | 96 | 2,194 |
| ff-16b-2c-44100hz.mp3 | 44100 | 1 | joint stereo | 128 | 2,924 |

Playlist containing all above files: ff-16b-mp3-playlist.m3u

Original music files: "Furious Freak" and "Galway", Kevin MacLeod (incompetech.com), Licensed under Creative Commons: By Attribution 3.0, http://creativecommons.org/licenses/by/3.0/

CHAPTER

FOUR

# RESOURCES

- Third party frameworks and libraries to develop audio applications with Espressif chips:
  - The JOSH operating system supports the ESP32 and can be used in scenarios such as intelligent voice interaction, smart home appliances, and smart gateways.
- Third party audio development modules and boards that work with ESP-ADF:
  - ESP32-A1S Audio Module equipped CodeC audio decoding chip that supports music playback and recording, and 4MB PSRAM. The module application schematic is available in datasheet.
- The esp32.com forum is a place to ask questions and find community resources. The forum has a section dedicated to ESP-ADF.
- This ESP Audio Development Framework inherits from ESP IoT Development Framework and you can learn about it in ESP-IDF Programming Guide.
- Check the Issues section on GitHub if you find a bug or have a feature request. Please check existing Issues before opening a new one.
- If you're interested in contributing to ESP Audio Development Framework, please check the Contributions Guide.
- Several books have been written about ESP32 and they are listed on Espressif web site.
- For additional ESP32 product related information, please refer to documentation Section of Espressif site.
- To buy audio development boards, check list of distributors under Get Samples on Espressif web site.

CHAPTER

FIVE

# COPYRIGHTS AND LICENSES

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Please refer to the COPYRIGHT in ESP-IDF Programming Guide

Where source code headers specify Copyright & License information, this information takes precedence over the summaries made here.

CHAPTER

SIX

# ENGLISH-CHINESE GLOSSARY

This document lists terms that are used in Espressif Audio Development Framework Guide and other audio related documentation. Each term is followed by its Chinese equivalents and some have definitions.

**AAC** Chinese equivalent: AAC

Abbreviation for Advanced Audio Coding, an industry-standard audio compression format.

**acoustic** Chinese equivalent:

**acoustic calibrator** Chinese equivalent:

Also known as sound level calibrator.

**acoustic echo cancellation** Chinese equivalent:

Spelled-out form of AEC.

**AEC** Chinese equivalent: AEC

Abbreviation for acoustic echo cancellation.

**Advanced Audio Distribution Profile** Chinese equivalent:

Spelled-out form of A2DP.

**A2DP** Chinese equivalent: A2DP.

Abbreviation for Advanced Audio Distribution Profile.

**A2DP sink** Chinese equivalent: A2DP sink

**A2DP source** Chinese equivalent: A2DP source

**AFE** Chinese equivalent: AFE

Abbreviation for audio front end. Espressif audio front-end algorithm framework is developed by Espressif AI Lab to provide high-quality and stable audio data to the host.

**AirKiss** Chinese equivalent: AirKiss

AirKiss is a quick-connection technique provided by Weixin device platform for Wi-Fi devices to configure network connection.

**AMR** Chinese equivalent: AMR

Abbreviation for Adaptive Multi-Rate, an audio compression format optimized for speech coding.

**AMR-NB** Chinese equivalent: AMR-NB

Abbreviation for Adaptive Multi-Rate Narrowband, a narrowband speech audio coding standard developed based on Adaptive Multi-Rate encoding.

**AMR-WB** Chinese equivalent: AMR-WB

Abbreviation for Adaptive Multi-Rate Wideband, a wideband speech audio coding standard developed based on Adaptive Multi-Rate encoding.

**analog-to-digital converter** Chinese equivalent:

Spelled-out form of ADC.

**ADC** Chinese equivalent: ADC

Abbreviation for analog-to-digital converter.

**audio codec** Chinese equivalent:

**audio forge** Chinese equivalent:

A combination of several audio backend processing techniques, including resample, downmix, automatic level control, equalizer and sonic. Users can enable or disable certain techniques as needed.

**audio gate** Chinese equivalent:

Spelled-out form of AG.

**AG** Chinese equivalent: AG

Abbreviation for audio gate.

**audio front end** Chinese equivalent:

Spelled-out form of AFE.

**audio passthru** Chinese equivalent:

Also known as pipeline passthru. It is an audio technique that allows audio files to pass through a pipeline unaltered.

**audio pipeline** Chinese equivalent:

Often used as "pipeline". It is a chain of audio processing elements arranged in a particular order so that the output of each element is the input of the next.

**Audio Video Remote Control Profile** Chinese equivalent:

Spelled-out form of AVRCP.

**AVRCP** Chinese equivalent: AVRCP

Abbreviation for Audio Video Remote Control Profile.

**automatic gain control** Chinese equivalent:

Spelled-out form of AGC.

**AGC** Chinese equivalent: AGC

Abbreviation for automatic gain control.

**automatic level control** Chinese equivalent:

Spelled-out form of ALC.

**ALC** Chinese equivalent: ALC

Abbreviation for automatic level control.

**automatic speech recognition** Chinese equivalent:

Spelled-out form of ASR.

**aux cable** Chinese equivalent: aux

Also known as auxiliary cable.

**ASR** Chinese equivalent: ASR

Abbreviation for automatic speech recognition.

**bandwidth** Chinese equivalent:

**Bass Frequency** Chinese equivalent:

**BCLK** Chinese equivalent: BCLK

Abbreviation for base clock.

**BluFi** Chinese equivalent: BluFi

A Wi-Fi network configuration function via Bluetooth channel. See ESP-IDF Programming Guide for more information.

**cavity** Chinese equivalent:

**command word** Chinese equivalent:

**core dump** Chinese equivalent:

**cutoff frequency** Chinese equivalent:

**decoder** Chinese equivalent:

**digital media renderer** Chinese equivalent:

Spelled-out form of DMR.

**digital signal processor** Chinese equivalent:

Spelled-out form of DSP.

**DSP** Chinese equivalent: DSP

Abbreviation for digital signal processor or digital signal processing.

**digital-to-analog converter** Chinese equivalent:

Spelled-out form of DAC.

**dispatcher** Chinese equivalent:

**distortion** Chinese equivalent:

**DAC** Chinese equivalent: DAC

Abbreviation for digital-to-analog converter.

**Digital Living Network Alliance** Chinese equivalent:

Spelled-out form of DLNA.

**DLNA** Chinese equivalent: DLNA

Abbreviation for Digital Living Network Alliance.

**DMR** Chinese equivalent: DMR

Abbreviation for digital media renderer.

**downmix** Chinese equivalent:

An audio processing technique that mixes more audio streams to less output audio streams.

**DuerOS** Chinese equivalent: DuerOS

DuerOS is a conversational AI system developed by Baidu.

**echo** Chinese equivalent:

A reflection of sound that arrives at the listener with a delay after the direct sound.

**echo reference signal** Chinese equivalent:

**electret condenser microphone** Chinese equivalent:

Spelled-out form of ECM.

**ECM** Chinese equivalent: ECM

Abbreviation for electret condenser microphone.

**element** Chinese equivalent:

Also known as audio element. It is the basic building block for the application programmer developing with ADF. Every decoder, encoder, filter, input stream, or output stream is in fact an audio element.

**encoder** Chinese equivalent:

**equalizer** Chinese equivalent:

**ESP VoIP** Chinese equivalent: ESP VoIP

ESP VoIP is a telephone client based on the standard SIP protocol, which can be used in some P2P or audio conference scenarios.

**fast Fourier transform** Chinese equivalent:

Spelled-out form of FFT.

**FFT** Chinese equivalent: FFT

Abbreviation for fast Fourier transform.

**FatFs** Chinese equivalent: FatFs

**FatFs stream** Chinese equivalent: FatFs

**FLAC** Chinese equivalent: FLAC

Abbreviation for Free Lossless Audio Codec, an audio coding format for lossless compression of digital audio.

**flexible pipeline** Chinese equivalent:

**FPS** Chinese equivalent: FPS

Abbreviation for frames per second.

**frames per second** Chinese equivalent:

Spelled-out form of FPS.

**frequency response** Chinese equivalent:

**full band** Chinese equivalent:

Spelled-out form of FB.

**FB** Chinese equivalent: FB

Abbreviation for full band.

**Hands-Free** Chinese equivalent:

Spelled-out form of HF.

**HF** Chinese equivalent: HF

Abbreviation for Hands-Free.

**Hands-Free Audio Gateway** Chinese equivalent:

Spelled-out form of HFP-AG.

**Hands-Free Profile** Chinese equivalent:

**Hands-Free Unit** Chinese equivalent:

**HFP** Chinese equivalent: HFP

Abbreviation for Hands-Free Profile.

**hardware abstraction layer** Chinese equivalent:

Spelled-out form of HAL.

**HAL** Chinese equivalent: HAL

Abbreviation for hardware abstraction layer.

**headset** Chinese equivalent:

**HFP-AG** Chinese equivalent: HFP-AG

Abbreviation for Hands-Free Audio Gateway.

**Hi-Fi speaker** Chinese equivalent:

Also known as high-fidelity speaker.

**High Frequency** Chinese equivalent:

**high-fidelity microphone** Chinese equivalent:

**HLS** Chinese equivalent: HLS

Abbreviation for HTTP Live Streaming.

**HTTP stream** Chinese equivalent: HTTP

**HTTP Live Streaming** Chinese equivalent: HTTP

Spelled-out form of HLS.

**I2S stream** Chinese equivalent: I2S

**insertion loss** Chinese equivalent:

**Internet radio** Chinese equivalent:

**Internet of Things** Chinese equivalent:

**IoT** Chinese equivalent: IoT

Abbreviation for Internet of Things.

**JPEG** Chinese equivalent: JPEG

A commonly used method of lossy compression for digital images. Same as JPG.

**JPG** Chinese equivalent: JPG

A commonly used method of lossy compression for digital images. Same as JPEG.

**Light and Versatile Graphics Library** Chinese equivalent:

Spelled-out form of LVGL

**low-pass filter** Chinese equivalent:

**LVGL** Chinese equivalent: LVGL

Abbreviation for Light and Versatile Graphics Library.

**M3U8** Chinese equivalent: M3U8

The Unicode version of M3U is M3U8, which uses UTF-8-encoded characters.

**M4A** Chinese equivalent: M4A

An audio encoding format for lossless compression of digital audio.

**mass production** Chinese equivalent:

**maximum output power** Chinese equivalent:

**MCLK** Chinese equivalent: MCLK

Abbreviation for master clock.

**mel-frequency cepstral coefficients** Chinese equivalent:

Spelled-out form of MFCC.

**MFCC** Chinese equivalent: MFCC

Abbreviation for mel-frequency cepstral coefficients.

**microphone** Chinese equivalent:

**mic** Chinese equivalent:

Informal form for microphone.

**micro-electro-mechanical systems microphone** Chinese equivalent:

Spelled-out form of MEMS mic.

**MEMS mic** Chinese equivalent: MEMS

Abbreviation for micro-electro-mechanical systems microphone.

**microphone gain** Chinese equivalent:

**microphone hole** Chinese equivalent:

**microSD card** Chinese equivalent: microSD

**MP3** Chinese equivalent: MP3

**MP4** Chinese equivalent: MP4

**MultiNet** Chinese equivalent: MultiNet

MultiNet is a lightweight model specially designed based on CRNN and CTC for the implementation of multi-command recognition.

**multi-room** Chinese equivalent:

**Multi-Room Music** Chinese equivalent: Multi-Room Music

ESP Multi-Room Music is a Wi-Fi-based communication protocol to share music across multiple interconnected speakers. Under this protocol, those connected speakers form a Group. They can play music synchronously and are controlled together, which can easily achieve a theater-grade stereo surround sound system.

**narrowband** Chinese equivalent:

Spelled-out form of NB.

**NB** Chinese equivalent: NB

Abbreviation for narrowband.

**NimBLE** Chinese equivalent: NimBLE

An open-source Bluetooth Low Energy or Bluetooth Smart stack.

**noise criteria curve** Chinese equivalent:

Also known as NC curve.

**noise rating curve** Chinese equivalent:

Also known as NR curve.

**noise floor** Chinese equivalent:

**noise suppression** Chinese equivalent:

Spelled-out form of NS.

**NS** Chinese equivalent: NS

Abbreviation for noise suppression.

**non-volatile storage** Chinese equivalent:

Spelled-out form of NVS.

**NVS** Chinese equivalent: NVS

Abbreviation for non-volatile storage.

**OGG** Chinese equivalent: OGG

An audio compression format.

**OPUS** Chinese equivalent: OPUS

A lossy audio coding format.

**PCM** Chinese equivalent: PCM

Abbreviation for pulse-code modulation.

**pixel** Chinese equivalent:

**playback** Chinese equivalent:

It is a noun. The verb is "play back".

**programmable gain amplifier** Chinese equivalent:

Spelled-out form of PGA.

**PGA** Chinese equivalent: PGA

Abbreviation for programmable gain amplifier.

**protractor** Chinese equivalent:

**pulse-code modulation** Chinese equivalent:

Spelled-out form of PCM.

**raw stream** Chinese equivalent:

**resample** Chinese equivalent:

**resample filter** Chinese equivalent:

**resonant frequency** Chinese equivalent:

**reverberation** Chinese equivalent:

**RGB** Chinese equivalent: RGB

The RGB color model is an additive color model in which the red, green, and blue primary colors of light are added together in various ways to reproduce a broad array of colors.

**ring buffer** Chinese equivalent:

**SBC** Chinese equivalent: SBC

Abbreviation for subband codec.

**SD card** Chinese equivalent: SD

**Session Initiation Protocol** Chinese equivalent:

Spelled-out form of SIP.

**signal-to-echo ratio** Chinese equivalent:

**signal-to-noise ratio** Chinese equivalent:

Spelled-out form of SNR.

**SIP** Chinese equivalent: SIP

Abbreviation for Session Initiation Protocol.

**SNR** Chinese equivalent: SNR

Abbreviation for signal-to-noise ratio.

**SmartConfig** Chinese equivalent: SmartConfig

The SmartConfig ™ is a provisioning technology developed by TI to connect a new Wi-Fi device to a Wi-Fi network. It uses a mobile app to broadcast the network credentials from a smartphone, or a tablet, to an un-provisioned Wi-Fi device.

**sonic** Chinese equivalent:

An audio processing technique that modifies sound frequency and speed.

**sound card** Chinese equivalent:

Also known as audio card.

**sound level meter** Chinese equivalent:

Also known as sound pressure level meter.

**sound pickup hole** Chinese equivalent:

**sound pickup tube** Chinese equivalent:

**sound transmission loss** Chinese equivalent:

Spelled-out form of STL.

**speech** Chinese equivalent:

**speech recognition** Chinese equivalent:

Spelled-out form of SR.

**SR** Chinese equivalent: SR

Abbreviation for speech recognition.

**SPI Flash File System** Chinese equivalent: SPI

Spelled-out form of SPIFFS.

**SPIFFS** Chinese equivalent: SPIFFS

Abbreviation for SPI Flash File System.

**SPIFFS stream** Chinese equivalent: SPIFFS

**subband codec** Chinese equivalent:

Spelled-out form of SBC.

**STL** Chinese equivalent: STL

Abbreviation for sound transmission loss.

**super wide band** Chinese equivalent:

Spelled-out form of SWB.

**SWB** Chinese equivalent: SWB

Abbreviation for super wide band.

**tape measure** Chinese equivalent:

**text-to-speech** Chinese equivalent:

Spelled-out form of TTS.

**TTS** Chinese equivalent: TTS

Abbreviation for text-to-speech.

**tolerance** Chinese equivalent:

**tone** Chinese equivalent:

**total harmonic distortion** Chinese equivalent:

Spelled-out form of THD.

**THD** Chinese equivalent: THD

Abbreviation for total harmonic distortion.

**voice activity detection** Chinese equivalent:

Spelled-out form of VAD.

**VAD** Chinese equivalent: VAD

Abbreviation for voice activity detection.

**VoIP** Chinese equivalent: VoIP

Abbreviation for Voice over Internet Protocol.

**wake word** Chinese equivalent:

**wake word engine** Chinese equivalent:

Spelled-out form of WWE.

**WakeNet** Chinese equivalent: WakeNet

WakeNet is a wake word engine built upon neural network for low-power embedded MCUs.

**wake-up** Chinese equivalent:

It is a noun.

**wideband** Chinese equivalent:

Spelled-out form of WB.

**WB** Chinese equivalent: WB

Abbreviation for wideband.

**WWE** Chinese equivalent: WWE

Abbreviation for wake word engine.

**YUV** Chinese equivalent: YUV

A color model typically used as part of a color image pipeline.

CHAPTER

SEVEN

# ABOUT

This is documentation of ESP-ADF, the framework to develop audio applications for ESP32 chip by Espressif.

The **ESP32** is 2.4 GHz Wi-Fi and Bluetooth combo, 32 bit dual core chip running up to 240 MHz, designed for mobile, wearable electronics, and Internet-of-Things (IoT) applications. It has several peripherals on board including I2S interfaces to easy integrate with dedicated audio chips. These hardware features together with the ESP-ADF software provide a powerful platform to implement audio applications including native wireless networking and powerful user interface.

The **ESP-ADF** provides a range of API components including **Audio Streams**, **Codecs** and **Services** organized in **Audio Pipeline**, all integrated with audio hardware through **Media HAL** and with **Peripherals** onboard of **ESP32**.

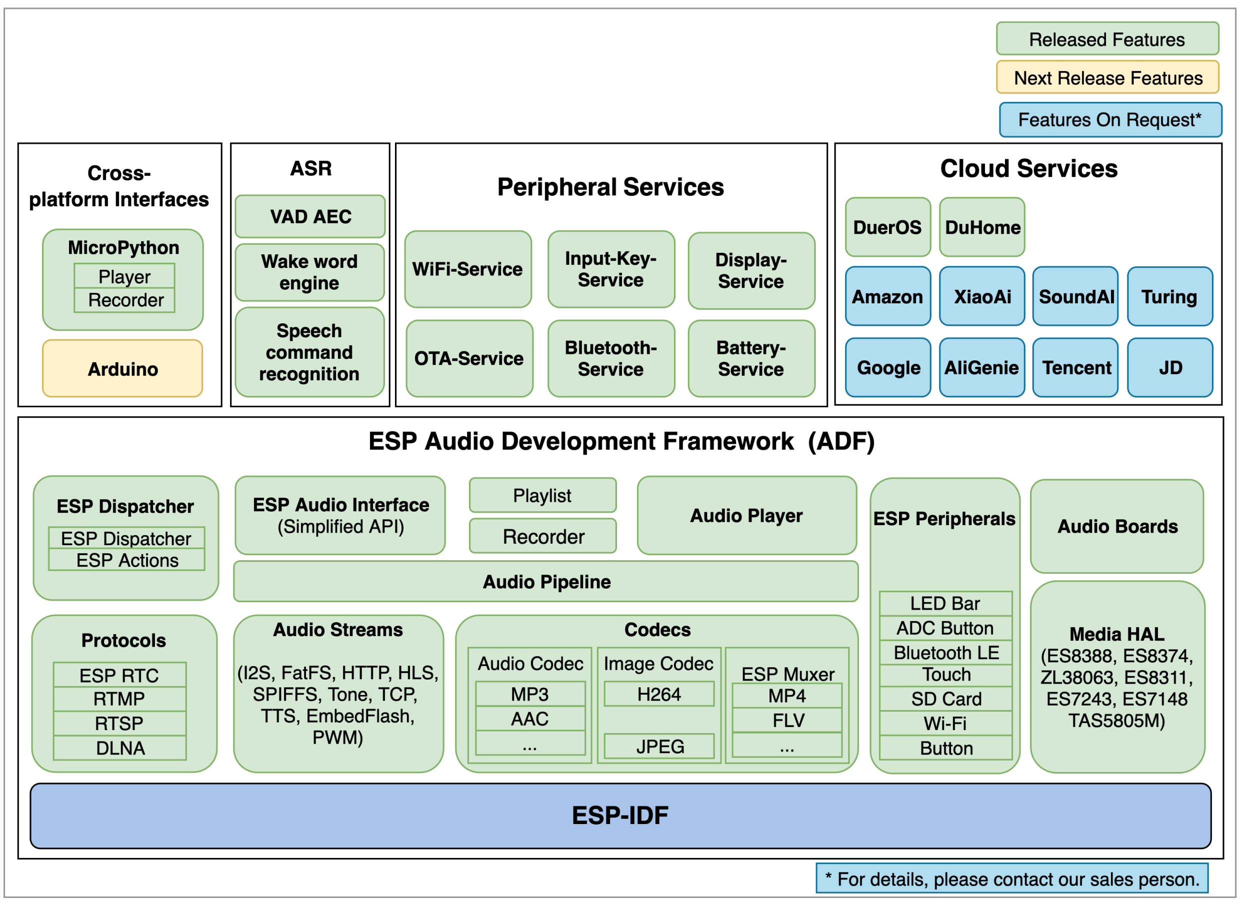


Fig. 1: Espressif Audio Development Framework

The ESP-ADF also provides integration with **Baidu DauerOS** cloud services. A range of components is coming to provide integration with DeepBrain, Amazon, Google, Alibaba and Turing cloud services.

The **ESP-ADF** builds on well established, FreeRTOS based, Espressif IOT Development Framework ESP-IDF.

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