



Airoha IoT SDK Application Developers Guide

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Document Revision History

Revision	Date	Description
1.0	31 July 2019	<ul style="list-style-type: none"> Initial release
1.0.1	14 August 2019	<ul style="list-style-type: none"> Added support for a different key action mapping table and configurable key action mapping table in key_remapper. Add support for synchronizing the LED patterns from Agent to Partner.
2.0.0	01 July 2020	<ul style="list-style-type: none"> Added support for 1565 and 1568 Added the description for the Ear Detection APP and Smart Charger APP Added the event APP_FIND_ME_EVENT_ID_TRIGGER to support triggering find me by other APPs.
2.1.0	23 November 2020	<ul style="list-style-type: none"> Added the description for the MCSync share APP.
2.1.1	29 September 2021	<ul style="list-style-type: none"> Added Race CMD of changing sidetone Added power save app and auto power off when silence detection.
3.0.0	11 January 2022	<ul style="list-style-type: none"> Added support for 158x The VP implementation on 158x is different from the last generation chipset.

Table of Contents

1.	Overview	1
1.1.	System architecture.....	1
1.2.	Folder structure	2
2.	Module introduction.....	3
2.1.	Event senders	3
2.1.1.	Battery event	3
2.1.2.	BT event	3
2.1.3.	Key event	3
2.2.	APPs	3
2.2.1.	Battery APP	4
2.2.2.	Homescreen App	5
2.2.3.	RHO APP	6
2.2.4.	HFP APP	6
2.2.5.	FindMe APP	8
2.2.6.	FOTA APP	9
2.2.7.	Music APP	9
2.2.8.	Ear detection APP	10
2.2.9.	Smart Charger APP.....	10
2.2.10.	MCSync share APP	11
2.2.11.	Power save APP	12
2.2.12.	Interaction events.....	13
2.3.	Config.....	13
2.3.1.	Key_remapper	13
2.3.2.	Led_manager	15
2.3.3.	VP_manager	15
2.4.	VP.....	16
3.	Feature options for MMI	17
4.	Customization.....	18
4.1.	Project settings	18
4.2.	Voice prompt	19
4.2.1.	Change voice prompt.....	19
4.2.2.	Call voice prompt in Code.....	23
4.3.	LED pattern	23
4.3.1.	Change LED patterns.....	23
4.3.2.	Call LED in code.....	25
4.4.	Modify AB15xx MMI key events	25
4.4.1.	EPT tool.....	25
4.4.2.	Airoha Tool Kit	27
4.4.3.	AB15xx key event.....	28
5.	FAQ.....	29
5.1.1.	How to change BLE advertising data?.....	29
5.1.2.	How do Agent and Partner communicate?	29
5.1.3.	What is a NVDM reserve list?	29
6.	Appendix	30

Lists of Tables and Figures

Table 1. Battery APP Status Definition	4
Table 2. Definitions of the BT State in the Homescreen APP	5
Table 3. Key Event Configurations	7
Table 4. States and Keys Handled by app_music	10
Table 5. Voice Prompt Index	30
Table 6. Foreground LED Patterns	30
Table 7. Background LED Patterns	31
Figure 1. System architecture of earbuds application layer	1
Figure 2. Key event sender	2
Figure 3. State machine in Smart Charger App	11
Figure 4. Interaction events sent between apps	13
Figure 5. The Flow for Getting the Key Action	14
Figure 6. Step 1 of the Config Tool	19
Figure 7. Step 2 of the Config Tool	19
Figure 8. Step 3 of the Config Tool (before sync)	20
Figure 9. Step 3 of the Config Tool (after sync)	20
Figure 10. Step 4 of the Config Tool (default folder)	21
Figure 11. Step 5 of the Config Tool (user files)	21
Figure 12. Step 6 of the Config Tool (scanning the working folder)	22
Figure 13. Step 6 of the Config Tool (adding VP)	22
Figure 14. Step 7 of the Config Tool	22
Figure 15. Binary files in build out folder	23
Figure 16. Step 2 of the LED pattern config	23
Figure 17. Step 4 of the LED pattern config (select item)	24
Figure 18. Step 4 of the LED pattern config (adjust parameters)	24
Figure 19. Parameters of LED patterns	24
Figure 20. EPT tool (tool button)	26
Figure 21. EPT tool (config)	26
Figure 22. Work flow for the EPT tool	27
Figure 23. Airoha Tool Kit timing config	28
Figure 24. Mapping table for the key action	28

1. Overview

This document helps developers to understand the design and code structure of Airoha IoT SDK application layer, and provides methods to do customizations.

This chapter introduces the system architecture of application layer of Airoha IoT SDK, include types of modules and the file structures. Based on this, the following chapters will illustrate the detail use of the modules and the customizations.

1.1. System architecture

As shown in Figure 1, the application layer of Airoha IoT SDK is composed of three kinds of modules: Event senders, APPs, and Config. Event senders send UI shell events to APPs. APPs receive the events and take actions to complete the applications. Configs manage the usage of keys, LEDs, and VP. Besides, there are also utilities such as the debugging tool and AWS sync senders which help fulfill modules.

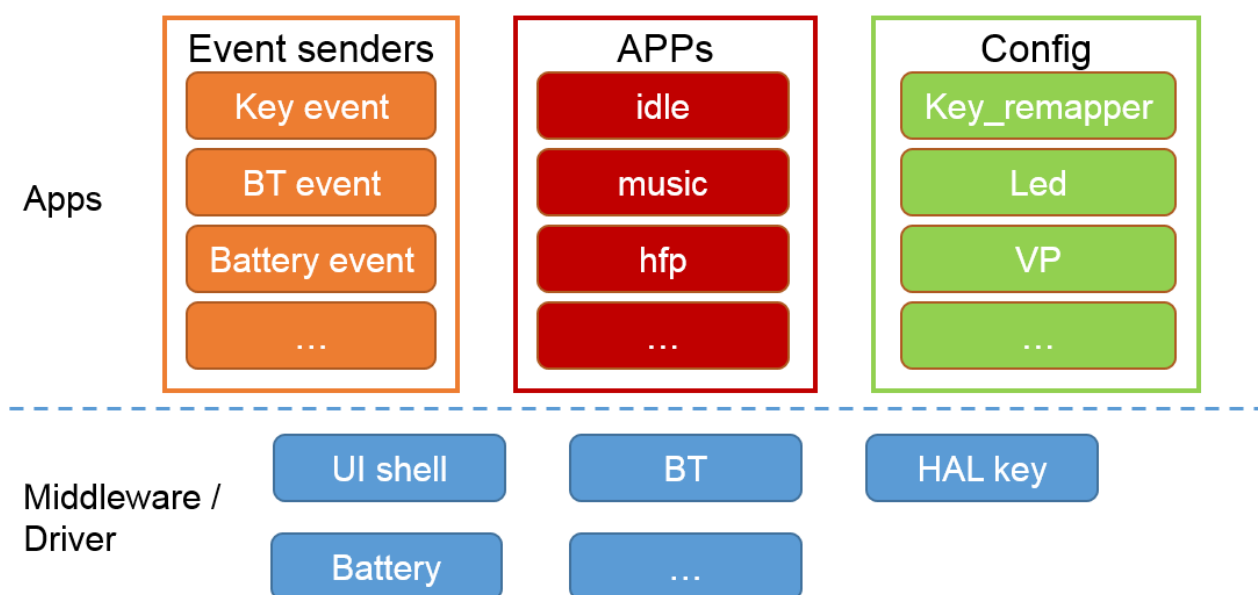


Figure 1. System architecture of earbuds application layer

Event Senders include key events, BT events, battery events and others. These modules register callbacks in middleware or hardware abstraction layer modules. When the callbacks are executed, the events are sent to APPs. Take the key event as an example:

- *Key event sender registers callback in HAL key module. It sends an event to UI shell when called. After receiving the event sent by the key event sender, the UI shell sends it to APPs.*

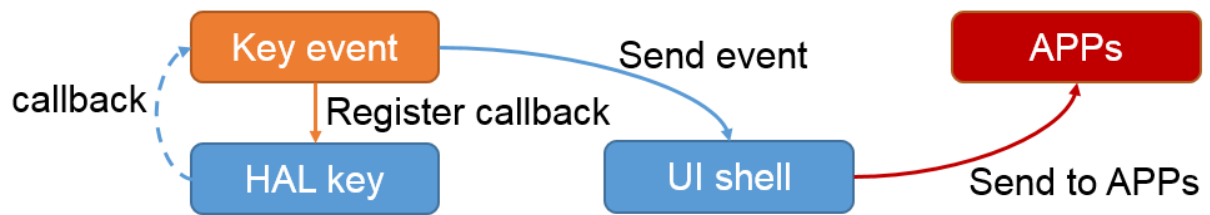


Figure 2. Key event sender

There are multiple folders named “app_***” as APPs, which implement UI logic. An APP is able to send events to another one for the request of taking some actions, or to notify the happening of some events.

Configs include Key Remappers, LED manager, and VP manager. Key Remappers provide a clear view of key usage in a table. For example, under connected status, short click is converted to KEY_AVRCP_PLAY.

1.2. Folder structure

The folders are listed below for your reference. Users who are interested in the detailed design of Airoha IoT SDK application can refer to the source code.

- APPs
/mcu/project/<board>/apps/<project>/src/apps/app_*
- Configs
/mcu/project/<board>/apps/<project>/src/apps/config
- Event sender
/mcu/project/<board>/apps/<project>/src/apps/events
- LED
/mcu/project/<board>/apps/<project>/src/apps/led
- VP
/mcu/project/<board>/apps/<project>/src/apps/vp
- Utils
/mcu/project/<board>/apps/<project>/src/apps/utils

2. Module introduction

Modules in event senders, APPs, and config are illustrated here.

2.1. Event senders

Event senders include three modules: battery event, BT event, and key event. These three modules are responsible for sending different events.

2.1.1. Battery event

This module sends `EVENT_GROUP_UI_SHELL_BATTERY` group events. The event IDs in this group are defined in `/mcu/project/<board>/apps/<project>/inc/apps/events/app_events_battery_event.h` as follow types:

- `APPS_EVENTS_BATTERY_PERCENT_CHANGE`
- `APPS_EVENTS_BATTERY_CHARGER_STATE_CHANGE`
- `APPS_EVENTS_BATTERY_CHARGER_EXIST_CHANGE`
- `APPS_EVENTS_BATTERY_SHUTDOWN_STATE_CHANGE`.

When the voltage of the device is less than the shutdown voltage, the battery event sends `APPS_EVENTS_BATTERY_SHUT_DOWN_STATE_CHANGE` to APPs.

2.1.2. BT event

This module sends three groups of events. The `EVENT_GROUP_UI_SHELL_BT_SINK` group is frequently used by APPs to get information about BT. The `EVENT_GROUP_UI_SHELL_BT_CONN_MANAGER` group and the `EVENT_GROUP_UI_SHELL_BT` group are helpful when the `EVENT_GROUP_UI_SHELL_BT_SINK` group cannot provide enough information.

- *`EVENT_GROUP_UI_SHELL_BT_SINK` group events – The event IDs of the group is defined in sink module in middleware. The BT state change and AWS connection change are notified by these events.*
- *`EVENT_GROUP_UI_SHELL_BT_CONN_MANAGER` group events – The event IDs of the group are defined in BT connection manager module in middleware. This group currently only contains the `BT_CONNECTION_MANAGER_EVENT_AIR_PAIRING_COMPLETE` event which is used to notify that the air pairing process is complete.*
- *`EVENT_GROUP_UI_SHELL_BT` group events – The event IDs of the group are defined in Bluetooth module in middleware. The event sender callback is registered where the app needs the BT messages.*

2.1.3. Key event

This module sends `EVENT_GROUP_UI_SHELL_KEY` group events. The event id of the group is composed of `key_id` and `airo_key_event`. For example, if the `key_id` is `DEVICE_KEY_POWER` (0x18) and the `airo_key_event` is `AIRO_KEY_SHORT_CLICK` (0x01), the event id is 0x0118. Please refer to `/mcu/project/<board>/apps/<project>/src/apps/events/app_events_key_events.c`.

2.2. APPs

APPs implement the actions of the applications layer and are organized by features and functions. Each APP is composed of one or more activities. The activities are managed by UI shell. Every activity receives events of the

EVENT_GROUP_UI_SHELL_SYSTEM group to follow the management to create, destroy, resume, pause, refresh and result. Please refer to Chapter 2.3 of the “Airoha_IoT_SDK_UI_Framework_Developers_Guide” document to get more about EVENT_GROUP_UI_SHELL_SYSTEM.

In the following section, we introduce the APPs in the Airoha IoT SDK. Customers can add others based on their own requirements.

2.2.1. Battery APP

This APP receives battery events and controls a state machine to support the features:

- Trigger system power off by sending REQUEST_POWER_OFF event when the battery is very low.
- Trigger RHO (Role Hand Over) when battery percentage of Agent is lower than Partner by sending TRIGGER_RHO event. To support this, Partner sends AWS data with the battery capacity/change of battery level or change of charger in status to Agent when AWS connected.
- Disable BT when charging in and enable BT when charging out by sending REQUEST_ON_OFF_BT events.
- Display LED pattern or play a voice prompt while in *Low capacity* or *charging* status.

The state definition of the battery APP is shown in Table 1. Battery APP Status Definition. The charger state 0 is CHARGER_STATE_CHR_OFF, 4 is CHARGER_STATE_EOC. APPS_BATTERY_LOW_THRESHOLD and APPS_BATTERY_FULL_THRESHOLD are defined in /mcu/project/<board>/apps/<project>/inc/apps/apps_customer_config.h.

Table 1. Battery APP Status Definition

Charger_exisit	Charger_state	Shut down state	Battery percent	Battery app Status
TRUE	= 0 or 4	N/A	N/A	Charging full
TRUE	!= 0 && != 4	N/A	N/A	Charging
FALSE	N/A	TRUE	N/A	Shut down
FALSE	N/A	FALSE	< low threshold	Low capacity
FALSE	N/A	FALSE	>= full threshold	Full
FALSE	N/A	FALSE	>= low threshold && < full threshold	Idle

Battery APP is composed of two activities: app_battery_idle_activity and app_battery_transient_activity. App_battery_idle_activity is created when the device is powered on, and app_battery_transient_activity is created by app_battery_idle_activity when a LED pattern is needed in a new state but not in an old state.

App_battery_idle_activity receives events of group EVENT_GROUP_UI_SHELL_BATTERY, EVENT_GROUP_UI_SHELL_BT_SINK and EVENT_GROUP_UI_SHELL_APP_INTERACTION, in addition to EVENT_GROUP_UI_SHELL_SYSTEM.

- EVENT_GROUP_UI_SHELL_BATTERY:

- Contains states of battery percent change, states of battery charge. App_battery_idle_activity manage battery app status according to these events and complete the features listed above.
- EVENT_GROUP_UI_SHELL_BT_SINK:
 - Contains the state change of BT connection, AWS connection, and profile connection update, which helps app_battery_idle_activity manage the context and battery app status.
 - For Partner, if an AWS connection is changed to connected, app_battery_idle_activity will notify Agent of its battery level. For Agent, if receives a Partner's battery level report, app_battery_idle_activity should check whether the device should do RHO.
- EVENT_GROUP_UI_SHELL_APP_INTERACTION
 - Receives APPS_EVENTS_INTERACTION_RHO_END event and refreshes the local context and battery app status.

2.2.2. Homescreen App

Homescreen APP works as settings. App_homescreen_idle_activity is the only activity of Homescreen APP, which is the priority when the system is in idle state.

- Homescreen APP processes the common key event requests, such as power_on, power_off, BT_discoverable, air_pairing, reconnect last device, reset paired device, and RHO to Agent.
- Before disabling BT, power off or reboot Agent. Homescreen APP may trigger RHO by sending TRIGGER_RHO.
- If the device is disconnected from a smartphone and waits for the time APPS_TIMEOUT_OF_SLEEP_AFTER_NO_CONNECTION (defined in /mcu/project/<board>/apps/<project>/inc/apps/apps_customer_config.h), Homescreen APP automatically triggers sleep mode.

The homescreen_idle_activity contains a BT connection component, which helps Homescreen APP to process BT and BT sink events and change the connection state of Homescreen APP. The relationship of BT state and connection state is shown in Table 2. Definitions of the BT State in the Homescreen APP:

- The connection state of Homescreen APP determines the LED patterns and voice prompt playback.
- On 1565/1568 or 158x, the BT sink state cannot express the BT connection state or BT power state, so we use BT_CM_EVENT_REMOTE_INFO_UPDATE and BT_CM_EVENT_POWER_STATE_UPDATE of BT connection manager events to decide the BT state.
- On 155x, specifically for Partner, BT sink state changing to CONNECTED means AWS is connected instead of connected to the smartphone.

Table 2. Definitions of the BT State in the Homescreen APP

BT state	Profile connected	BT visible	Connection state
NONE	N/A	N/A	BT OFF
POWER_ON	N/A	TRUE	Discoverable (Only on Agent)
POWER_ON	N/A	FALSE	Non-discoverable

BT state	Profile connected	BT visible	Connection state
>= CONNECTED	FALSE	FALSE	Non-discoverable
>= CONNECTED	TRUE	FALSE	Connected to SP

2.2.3. RHO APP

This APP receives and processes TRIGGER_RHO request, and sends RHO_STARTED and RHO_END events to notify other APPs of the RHO status. The APP will start RHO only when the AWS connection is established as well as BT is connected to the smartphone. Otherwise, it immediately sends a RHO_END event.

App_rho_idle_activity process events of groups EVENT_GROUP_UI_SHELL_BT_SINK and EVENT_GROUP_UI_SHELL_APP_INTERACTION in addition to EVENT_GROUP_UI_SHELL_SYSTEM.

- EVENT_GROUP_UI_SHELL_BT_SINK
 - Contains state change of the BT connection, AWS connection and profile connection update, which helps app_rho_idle_activity manage local context. The context remembers the state of BT sink, and helps the APP to determine whether RHO can be started now.
- EVENT_GROUP_UI_SHELL_APP_INTERACTION
 - Contains TRIGGER_RHO and RHO_END. The APP checks the states and do RHO when it receives TRIGGER_RHO event.

2.2.4. HFP APP

This APP receives and processes events of BT_SINK, KEY, and BATTERY groups, and contains two activities: *app_hfp_idle_activity* and *app_hfp_activity*. The former is created when the device is powered on. The latter starts when BT sink state changes to the range of HFP, and is completes by itself when BT sink state changes to CONNECTED or POWER_OFF.

App_hfp_idle_activity processes events of groups EVENT_GROUP_UI_SHELL_KEY, EVENT_GROUP_UI_SHELL_BT_SINK and EVENT_GROUP_UI_SHELL_BATTERY in addition to EVENT_GROUP_UI_SHELL_SYSTEM.

- EVENT_GROUP_UI_SHELL_KEY
 - This group is used to notify that the voice assistant waked up and sets VP playback or redials the last call.
- EVENT_GROUP_UI_SHELL_BT_SINK
 - When BT_SINK_SRV_EVENT_STATE_CHANGE event is received, app_hfp_idle_activity checks the state and starts app_hfp_activity.
 - When BT_SINK_SRV_EVENT_PROFILE_CONNECTION_UPDATE event is received and notify that the profile connected, app_hfp_idle_activity reports battery level to the remote device.
- EVENT_GROUP_UI_SHELL_BATTERY

- When APPS_EVENTS_BATTERY_PERCENT_CHANGE is received, the APP reports the battery level to the smartphone if it is connected. The smartphone shows a battery icon in the status bar if it supports this feature.

App_hfp_activity processes events of groups EVENT_GROUP_UI_SHELL_KEY, EVENT_GROUP_UI_SHELL_BT_SINK and EVENT_GROUP_UI_SHELL_APP_INTERACTION besides EVENT_GROUP_UI_SHELL_SYSTEM.

- EVENT_GROUP_UI_SHELL_KEY
 - When received events of EVENT_GROUP_UI_SHELL_KEY group, app_hfp_activity will execute actions by processing key events and the current state according to Table 3. Key Event Configurations. The configurations are in the file `/mcu/project/<board>/apps/<project>/src/broads/<board>/customerized_key_config.c`.

Table 3. Key Event Configurations

HFP State	Short key	Double key
BT_SINK_SRV_STATE_INCOMING	Accept Call	Reject Call
BT_SINK_SRV_STATE_OUTGOING	End Call	Hold Call
BT_SINK_SRV_STATE_ACTIVE	End Call	Hold Call
BT_SINK_SRV_STATE_TWC_INCOMING	Accept Call	Reject Call
BT_SINK_SRV_STATE_TWC_OUTGOING	N/A	Hold Call
BT_SINK_SRV_STATE_HELD_ACTIVE	End Call	Hold Call
BT_SINK_SRV_STATE_HELD_REMAINING	End Call	Hold Call
BT_SINK_SRV_STATE_MULTIPARTY	End Call	N/A

- EVENT_GROUP_UI_SHELL_BT_SINK
 - HFP state changes by BT sink state. App_hfp_activity sets different LED BG patterns and plays different VPs according to HFP state changes. For example, there are two methods to notify the user that there is an incoming call:
 - If the smartphone sends in-band ringtone to the device, the product plays in-band ringtone.
 - If smartphone does not send in-band ringtone, the device plays the voice prompt. This voice prompt is special for it will loop until the state of the call is changed.
- EVENT_GROUP_UI_SHELL_APP_INTERACTION
 - When APPS_EVENTS_INTERACTION_UPDATE_LED_BG_PATTERN event is received, the APP will set background LED according to its state.
 - When APPS_EVENTS_INTERACTION_UPDATE_MMI_STATE event is received, the APP will set MMI state.

- When APPS_EVENTS_INTERACTION_RHO_END or APPS_EVENTS_INTERACTION_PARTNER_SWITCH_TO_AGENT event is received, the APP will decide whether to set VP playback or not according to its state.

The app support use key or rotary to change the sidetone level. The function

apps_config_audio_helper_set_sidetone_value() is used to change the sidetone value. The sidetone can also be enabled, disabled or have its value changed by the race CMD

The CMD for changing the sidetone enable or disable is "05 5A 05 00 82 2C 07 00 <00 or 01>" – The last byte 00 is disable, 01 is enable.

The CMD for changing the sidetone value is "05 5A 06 00 82 2C 06 00 <XX YY>" – The last 2 bytes means the target value is 0xYYXX.

2.2.5. FindMe APP

FindMe APP is developed for users to find the device if needed. While the device receives a FindMe command, the LED pattern and VP playback may be set by the APP for users to soon see the device.

This APP is composed of two activities: *app_fm_idle_activity* and *app_fm_activity*, and processes events of EVENT_GROUP_UI_SHELL_FINDME group and EVENT_GROUP_UI_SHELL_APP_INTERACTION group. The *app_fm_idle_activity* is created when the device is powered on. It starts *app_fm_activity* while it receives a RACE_EVENT_TYPE_FIND_ME event which is one of the FINDME group events.

App_fm_activity processes events of groups EVENT_GROUP_UI_SHELL_KEY, EVENT_GROUP_UI_SHELL_FINDME and EVENT_GROUP_UI_SHELL_APP_INTERACTION.

- EVENT_GROUP_UI_SHELL_KEY
 - *The event will be sent when user presses a key on the device and is received by the APP to stop the current FINDME request.*
- EVENT_GROUP_UI_SHELL_FINDME
 - To trigger FINDME, the smartphone will send a RACE CMD to the device. After receiving the RACE CMD, the device will send an APP_FIND_ME_EVENT_ID_TRIGGER event which includes three parts of data: *is_blink*, *is_tone* and *duration_seconds*. When APP_FIND_ME_EVENT_ID_TRIGGER is received, the *app_fm_activity* will decide whether to set LED patterns and play VPs according to the parameters received.
 - If *is_tone* is 1, the activity will start playing the FINDME VP and send a APPS_EVENTS_INTERACTION_PLAY_FIND_ME_TONE event with a delay time to itself through API *ui_shell_send_event()*. The activity will play the voice prompt and send the same event with the delay time again while received the event.
 - The delay time is 4 seconds which is defined as FINDME_EVENT_TIMER_INTERVAL, and if the *duration_seconds* is 0, total time for one FINDME request is 30 seconds which is defined as FINDME_TOTAL_TIME. The *app_fm_activity* will remember the current count of VP playback, and finish itself after the voice prompt played for a total of 5 times.
 - A FINDME request should be stopped when the next FINDME request comes, even if the previous one has not been finished.
- EVENT_GROUP_UI_SHELL_APP_INTERACTION
 - When APPS_EVENTS_INTERACTION_UPDATE_LED_BG_PATTERN event is received, the APP will set background LED.

- When APPS_EVENTS_INTERACTION_UPDATE_MMI_STATE event is received, the APP will set MMI state.
- When APPS_EVENTS_INTERACTION_PLAY_FIND_ME_TONE event is received, the APP will set FindMe VP playback.

2.2.6. FOTA APP

This APP is completed by app_fota_idle_activity, who receives and processes FOTA_START event, FOTA_CANCEL event and FOTA_NEED_REBOOT event.

- *When received FOTA_START, the app will play VP and set LED pattern.*
- *When received FOTA_CANCEL, the app will only set LED pattern.*
- *When received FOTA_NEED_REBOOT when FOTA finishes download, the APP will broadcast this event.*

2.2.7. Music APP

Music APP controls the playback of music. This APP is composed of two activities: *app_music_idle_activity* and *app_music_activity*. The idle activity is created when the device is powered on and the music activity will be started while streaming.

App_music_idle_activity processes events of groups EVENT_GROUP_UI_SHELL_KEY and EVENT_GROUP_UI_SHELL_BT_SINK.

- EVENT_GROUP_UI_SHELL_KEY
 - The key event handled by app_music_idle_activity is shown in Table 4. States and Keys Handled by app_music.
- EVENT_GROUP_UI_SHELL_BT_SINK
 - When BT_SINK_SRV_EVENT_STATE_CHANGE event is received, the APP will check whether the state is changed to streaming and start app_music_activity.
 - When BT_SINK_SRV_EVENT_AWS_MCE_STATE_CHANGE or BT_SINK_SRV_EVENT_PROFILE_CONNECTION_UPDATE event is received, the APP will update and check the states to do audio channel set.
 - When Agent and Partner are connected and Partner is not charging, both audio channels should be stereo.
 - Otherwise, Agent should be mono.

App_music_activity processes events of groups EVENT_GROUP_UI_SHELL_KEY, EVENT_GROUP_UI_SHELL_BT_SINK and EVENT_GROUP_UI_SHELL_APP_INTERACTION.

- EVENT_GROUP_UI_SHELL_KEY
 - The key event handled by app_music_activity is shown in Table 4. States and Keys Handled by app_music.
- EVENT_GROUP_UI_SHELL_BT_SINK
 - When BT_SINK_SRV_EVENT_STATE_CHANGE event is received, the APP will check whether the streaming is ended and finish itself.
- EVENT_GROUP_UI_SHELL_APP_INTERACTION

- When APPS_EVENTS_INTERACTION_UPDATE_MMI_STATE event is received, the APP will set the MMI state.

Table 4. States and Keys Handled by app_music

Activity	State	Key handle
Music idle activity	Power on; Connected	Play
Music activity	Streaming	Pause; Next / Forward; Volume Up/Down;

2.2.8. Ear detection APP

This APP is used to detect the wearing status of earbuds and report it to other apps. This APP is completed by app_in_ear_idle_activity.

This APP does not control the playback of music, playback is controlled by the music APP. The music APP receives event APPS_EVENTS_INTERACTION_IN_EAR_UPDATE_STA from the Ear detection APP and plays or pauses music according to the current status. When the status is updated, if Agent was taken off and Partner is still wearing or only Partner is put on, app_in_ear_idle_activity will trigger RHO.

App_in_ear_idle_activity process events of groups EVENT_GROUP_UI_SHELL_BT_SINK and EVENT_GROUP_UI_SHELL_APP_INTERACTION in addition to EVENT_GROUP_UI_SHELL_SYSTEM.

- EVENT_GROUP_UI_SHELL_BT_SINK
 - When BT_AWS_MCE_AGENT_STATE_INACTIVE event is received, app_in_ear_idle_activity will update status.
 - When BT_SINK_SRV_EVENT_PROFILE_CONNECTION_UPDATE event is received, the Partner will update status to Agent.
- EVENT_GROUP_UI_SHELL_APP_INTERACTION
 - The APPS_EVENTS_INTERACTION_UPDATE_IN_EAR_STA_EFFECT will be sent when the sensor detects that the earbuds are put on or taken off. When this event is received, the APP will update status for Agent, or the APP will update Partner's status to Agent.

2.2.9. Smart Charger APP

This APP could receive event from Smart Charger middleware and control state machine.

The state machine is as below:

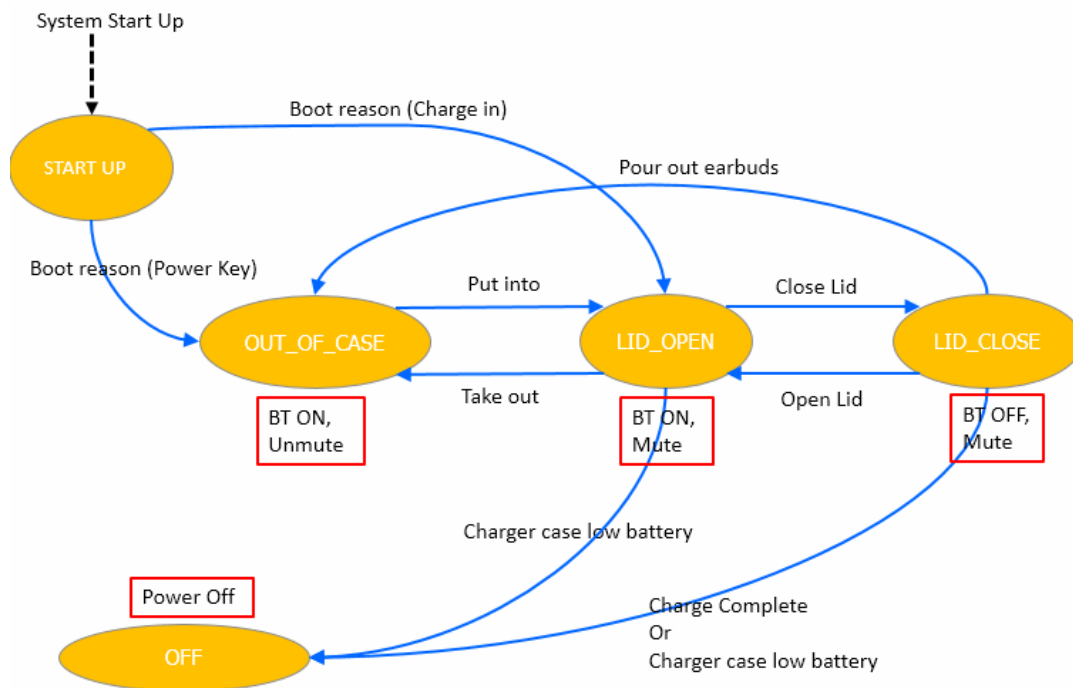


Figure 3. State machine in Smart Charger App

Smart Charger APP RHO scenario:

- Agent is in the charger case , but Partner is out of the case
- The battery percent of Partner is 30% greater than Agent

Other APP could get Smart Charger Case action and battery information by monitoring EVENT_ID_SMCHARGER_NOTIFY_PUBLIC_EVENT event of EVENT_GROUP_UI_SHELL_CHARGER_CASE group.

The design of Smart Charger Case should match with Smart Charger middleware, such as command/response payload, command sending delay, etc. For more developer details of Smart Charger Case, please refer to <One-Wire UART Smart Charger Case design.ppt>.

2.2.10. MCSync share APP

This APP provides a UI for entering or exiting MCSync share. It also handles RHO events for MCSync share. This APP is composed of two activities: *app_share_idle_activity* and *app_share_activity*.

App_share_idle_activity is used to receive events to enter MCSync share. These events come from the Key and Race commands. If the user sends the request of enter MCSync share through the Race command, the request is converted into the key event to enter MCSync share. The *app_share_idle_activity* handles the follow events:

- EVENT_GROUP_UI_SHELL_KEY
 - If the key action id is KEY_SHARE_MODE_SWITCH or KEY_SHARE_MODE_FOLLOWER_SWITCH, *app_share_idle_activity* will try to enter MCSync share and create *app_share_activity* to handle the events in sharing status. But if the current role is Partner, this event is sent to Agent.
- EVENT_GROUP_UI_SHELL_APP_INTERACTION

- When the APPS_EVENTS_INTERACTION_SHARE_MODE_STA_UPDATE event is received, the app checks the status of MCSync share. If the current status is already in sharing or preparing status, the app_share_idle_activity creates app_share_activity.
- EVENT_GROUP_UI_SHELL_BT_CONN_MANAGER
 - Before entering MCSync share, if there are two smart phones connected with earbuds, the APP disconnects the inactive smart phone and will be pending on the action of enter MCSync share until the earbuds are completely disconnected from the inactive phone. This activity will then handle the BT_CM_EVENT_REMOTE_INFO_UPDATE event to check the connection status and try to enter MCSync share again.

App_share_activity is used to receive events to exit MCSync share. It also manages the status of MCSync share. If the current status is preparing or sharing, the RHO is not allowed.

In addition to exiting from MCSync share by user, if the user puts any earbuds into the charger case or powers off any earbuds, all earbuds will exit MCSync share. In these cases, the RHO is allowed but will be pending until the earbuds completely exit MCSync share.

The app_share_activity processes the follow events:

- EVENT_GROUP_UI_SHELL_KEY
 - If the key action id is KEY_SHARE_MODE_SWITCH or KEY_SHARE_MODE_FOLLOWER_SWITCH, app_share_activity will try to exit MCSync share. This activity will finish by itself when earbuds completely exit MCSync share.
- EVENT_GROUP_UI_SHELL_APP_INTERACTION
 - When the APPS_EVENTS_INTERACTION_SHARE_MODE_STA_UPDATE event is received, this activity checks the status MCSync status. If the current status is not preparing or sharing, app_share_activity will finish by itself.
 - When APPS_EVENTS_INTERACTION_POWER_OFF event received, this activity will try to exit MCSync share and be pending on the possible RHO.
- EVENT_GROUP_UI_SHELL_BATTERY
 - When APPS_EVENTS_BATTERY_CHARGER_EXIST_CHANGE event received, this activity will check the charging status. If currently charging, this activity will also try to exit MCSync share and be pending on the possible RHO.

2.2.11. Power save APP

Power save app manages system power off or BT power off automatically to save power.

The function app_power_save_utils_get_target_mode() can return current power saving target mode. The target mode has three levels: NORMAL means does not need power off; BT_OFF means it must power off BT but it keeps the system on; SYSTEM_OFF means it must do system power off. Normally the target state is idle when BT is not connected or silence is detected. Some other modules can still use app_power_save_utils_add_new_callback_func() to register a callback and call and app_power_save_utils_notify_mode_changed() to notify that the state has changed. When the power save app gets target mode, the callback will be called and can return to its mode. For example, when BT is not connected and USB audio is connected, the USB audio module does not want to do system off, so it can return to BT_off.

Power save app has three states: Idle state means it does not need to power save; Waiting state means it needs to do power save but must wait until timeout; and Timeout state means it needs to do power save and has already timeout so it must power off immediately.

In AWS projects, the Partner stays in idle state when AWS is connected. The Agent will send a power off request to Partner to make sure both sides can power off at the same time.

The waiting time is different when BT is not connected and silence is detected; Default is 5 minutes when BT is not connected and 20 minutes when silence is detected.

The power save feature is enabled when APPS_SLEEP_AFTER_NO_CONNECTION is y. The power off when silence detected feature is enabled when AIR_SILENCE_DETECTION_ENABLE is y. They can also be disabled dynamically by smart phone APP; you can review the function `app_power_save_utils_set_cfg()` and `app_power_save_utils_set_cfg()` to understand it.

2.2.12. Interaction events

The interaction events are sent by APPs. Here are three typical scenarios of interaction events:

- An APP sends an event to itself.
- An APP sends `UPDATE_LED_BG_PATTERN` event. The event is passed in activity stack from top to bottom. One of the activities sets the background LED pattern and returns `TRUE` after processing so that all the next activities will not receive the event.
- An APP can send a request event and another APP processes the request when it receives the event. The relationship is as shown below:

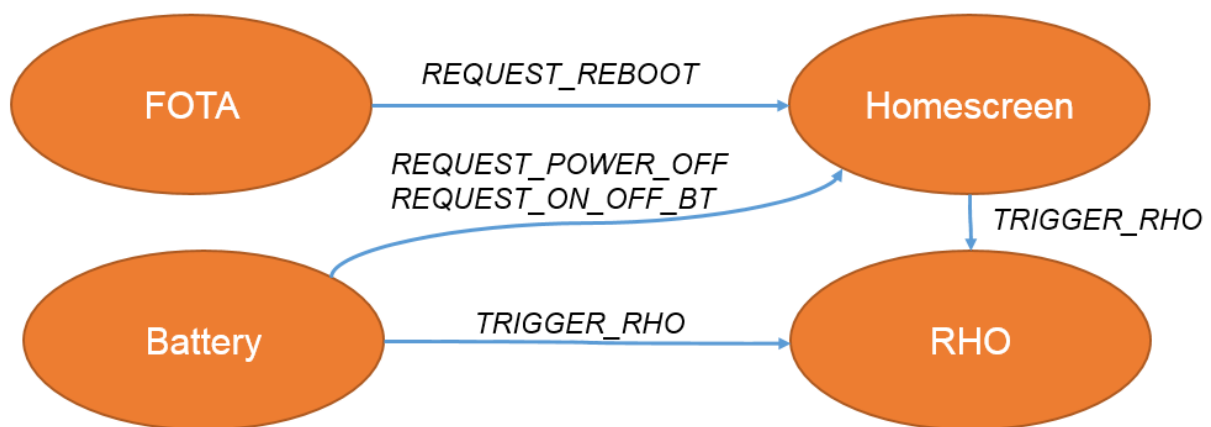


Figure 4. Interaction events sent between apps

2.3. Config

Config modules implement the management of what actions will be taken by the device when the user pressed a key, and what LED pattern and voice prompt playback should be seen in some situations. The configurations of these modules are decided by project customization, which will be introduced in Chapter 4.

2.3.1. Key_remapper

The actions to be taken when key pressed are decided by current states and key configs. The mapping method is provided in `key_remapper`. The mapping tables are defined in

/mcu/project/<board>/apps/<project>/src/<board_type>/customerized_key_config.c. Key_remapper module uses key_id, key_event and the current MMI state as input to query action in the mapping tables.

There are three mapping tables in current design: Two tables are default (i.e. non-configurable) mapping tables; One is used when the device is configured as left side; The other is used when the device is configured as right side or not yet configured to left nor right.

The last one of the three mapping tables is a configurable mapping table which has higher priority (please refer to Figure 5. The Flow for Getting the Key Action for reference). The configurable table can be configured by smartphone APP.

APPs call functions provided by this module to map key event. The input parameters are *key_id* and *airo_key_event*. The output is an action, which is an ENUM type named *apps_config_event_t*. Please refer to /mcu/project/<board>/apps/<project>/src/apps/config/apps_config_key_remapper.c.

Current state is defined in key_remapper module, and can be set by APPs through function *apps_config_key_set_mmi_state()*. The MMI state is usually set by activities who receives an APPS_EVENTS_INTERACTION_UPDATE_MMI_STATE event. The activity should return TRUE after handling the event to avoid the next activity receiving it.

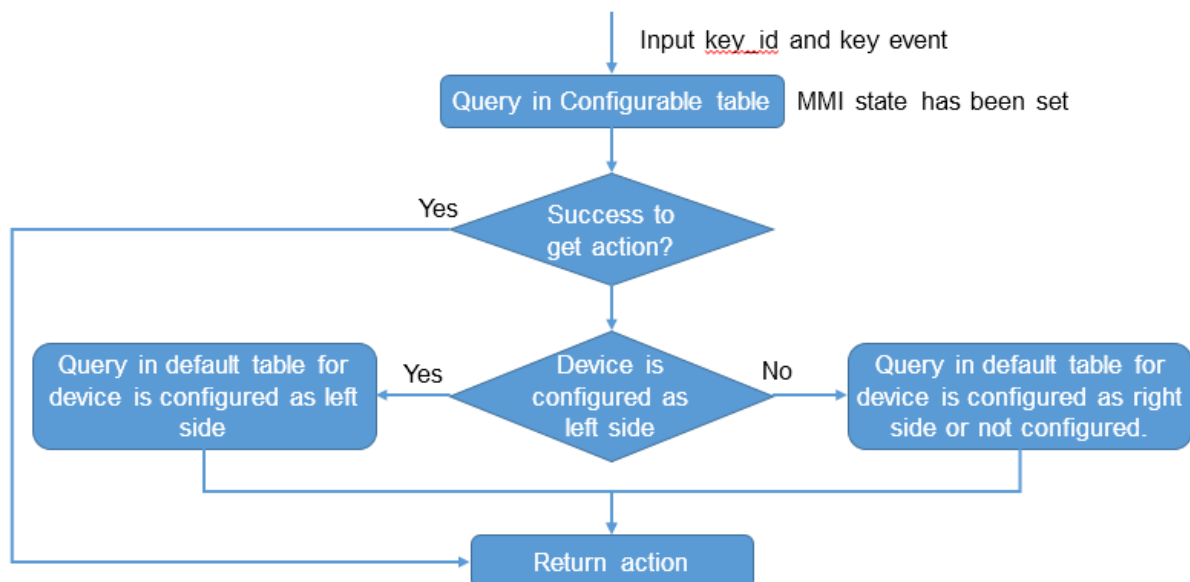


Figure 5. The Flow for Getting the Key Action

APIs:

- *apps_config_key_action_t apps_config_key_event_remapper_map_action(uint8_t key_id, airo_key_event_t key_event):* get the key action in key_event map.
- *void apps_config_key_set_mmi_state(apps_config_state_t state):* set the current state of the MMI.
- *apps_config_state_t apps_config_key_get_mmi_state(void):* get the current state of the MMI.
- *void apps_config_key_remapper_init_configurable_table(void):* initialize the configurable key

2.3.2. Led_manager

APPs call functions provided by this module to control LED patterns. Foreground and background LED patterns are supported, and the foreground LED patterns have higher priorities and need a timeout period as parameter. This module calls APIs provided by LED module to set LED patterns.

Normally background LED patterns are set by activities who receives an APPS_EVENTS_INTERACTION_UPDATE_LED_BG_PATTERN event. The activity should return TRUE after handling the event to avoid the next activity receiving it.

Both the foreground pattern and background pattern can be synchronized from Agent to Partner but there are two other notable conditions:

- *Foreground patterns indicate that an event occurs: Partner led pattern will show fewer led patterns, no matter whether it is local or synchronized from Agent.*
- *Background patterns indicate the states which may be kept for an extended period of time: For background pattern, a parameter “priority” will be referred. If the “priority” of the local background LED pattern on the Partner side is higher than the pattern which is synchronized from Agent, Partner must show the local background LED pattern and vice versa.*

APIs:

- *void apps_config_led_manager_init(void): init led manager module when the system is started.*
- *bool apps_config_set_background_led_pattern(uint8_t index, bool need_sync, apps_config_led_manager_aws_sync_priority_t priority): set background LED pattern.*
- *bool apps_config_set_foreground_led_pattern(uint8_t index, uint16_t timeout, bool need_sync): set foreground LED pattern.*

The foreground and background LED pattern list is shown in

Table 6 and

Table 7 in the appendix. Normally, the background pattern indicates the current system states. To save power, charging full, playing music and connected states use LED_INDEX_IDLE LED pattern.

2.3.3. VP_manager

APPs call functions provided by this module to control the voice prompt playback. This module is only supported on 155x and 1565/1568.

There are 3 types of voice prompts and the APIs to start and stop them:

- normal voice prompt:
Start: apps_config_set_vp()
Stop: apps_config_stop_vp()
- voice number : phone number of incoming
Start: app_config_set_voice()
Stop: apps_config_stop_voice()
- ringtone: a voice prompt that can be played back.
Start: app_config_set_voice()
Stop: apps_config_stop_voice()

Language change is supported by VP_manager.

Table 5 in the appendix shows the voice prompt priorities and indexes in different conditions. If a voice prompt with a higher priority is set when another voice prompt is playing, it will be played immediately and the current one dropped or it will be put in the right position of the VP playback queue according to priorities.

For more detailed information, please refer to description of the functions.

2.4. VP

VP module implements the voice prompt management and play control of the platform. It provides APIs for upper layers to play or stop playing VP. This module is not supported on 155x and 1565/1568.

The VP index list is in `app_config_vp_index_list.h`.

APIs:

- `voice_prompt_status_t voice_prompt_play(voice_prompt_param_t *vp, uint16_t *play_id)`: play VP.
- `voice_prompt_status_t voice_prompt_update_control(uint16_t play_id, voice_prompt_param_t *vp)`: update control parameters of a playing VP.
- `voice_prompt_status_t voice_prompt_play_on_peer(bt_aws_mce_role_t target_role, voice_prompt_param_t *vp)`: Partner notify Agent to play VP.
- `voice_prompt_status_t voice_prompt_stop(uint32_t vp_index, uint16_t id, bool sync)`: stop a VP.
- `voice_prompt_status_t voice_prompt_clear_all(void)`: stop all the VPs in the queue.
- `voice_prompt_status_t voice_prompt_stop_on_peer(uint32_t vp_index, bool sync)`: Partner notify Agent to stop a VP.
- `uint32_t voice_prompt_get_current_index()`: get the current playing VP index.

You can refer to `voice_prompt_api.h` for detail introduction of the usage the each API.

3. Feature options for MMI

Feature options can be controlled in feature.mk for some common scenarios of users. For example:

- *APPS_DISABLE_BT_WHEN_CHARGING: Disable BT while the device is being charged.*
- *APPS_AUTO_TRIGGER_RHO: Trigger RHO before power off, disable BT and when the battery level of Agent is lower than Partner.*
- *APPS_SLEEP_AFTER_NO_CONNECTION: Start a timer to sleep when the device isn't connected to the smartphone.*
- *AIR_SILENCE_DETECTION_ENABLE: Support auto power off when DSP detected audio is not playing or is a silent stream. The option must be simultaneously enabled on the CM4 and DSP sides.*

For more features and details, please refer to /mcu/project/<project_path>/src/apps/module.mk.

4. Customization

Customers can change configurations through ConfigTool or software code.

ConfigTool can be used to change the parameters and data for fine-tuning and also some feature options for factory producing. They are:

- LED patterns
- VP file table
- BT name
- MP Test Mode and DUT Mode

A software configuration is a macro or a variable which is defined in a *.c or *.h file. The following list shows some examples:

- *A configuration can be a parameter or a feature option that affects limited code in *.c files.*
- *The parameters of APP features are defined in /mcu/project/<board>/apps/<project>/inc/apps/apps_customer_config.h, such as*
- *Air pairing key and air pairing duration.*
- *Support of enabling BT discoverable mode when disconnected from smartphone.*
- *Some configurations for BT middleware features are defined in /mcu/project/<board>/apps/<project>/src/apps/bt_customer_config.c. For example,*
- *The rule of deciding who is Agent in air pairing*
- *default volume*
- *HFP feature*

4.1. Project settings

BOARD_TYPE

- Defined in mcu/project/<project_path>/GCC/feature_XXX.mk.
- It is used to decide which folders in /config_bin, /ept_config, /inc and /src are included.
 - For example, if GCC/feature_ab1552_evk.mk is used and defines BOARD_TYPE = ab1552_evk, the folders /config_bin/ab1552_evk, /ept_config/ab1552_evk and /inc/ab1552_evk, /src/ab1552_evk will be included in the project.

Serial port configuration

- Can be changed through the macros defined in /inc/<board_type>/serial_port_assignment.h.

nvdm.bin and filesystem.bin are in folder /ept_config/<board_type>.

- The nvdm.bin is based on nvkey.xml which is in the same folder.
- nvdm.bin and filesystem.bin can be changed by ConfigTool. Please refer to the document AB155x_AM255x_Config_Tool_Users_Guide or AB157x_AB158x_Series_Config_Tool_Users_Guide.

4.2. Voice prompt

Customers can add voice prompt source and change the configurations of the VP playback, as well as select the language you use. Noted, only MP3 file is supported to be added as source and only Chinese and English are supported in language usage.

4.2.1. Change voice prompt

To use ConfigTool to change voice prompt, complete the following procedure:

- 1) Open AB155x ConfigTool and click *Open File* to load the firmware.

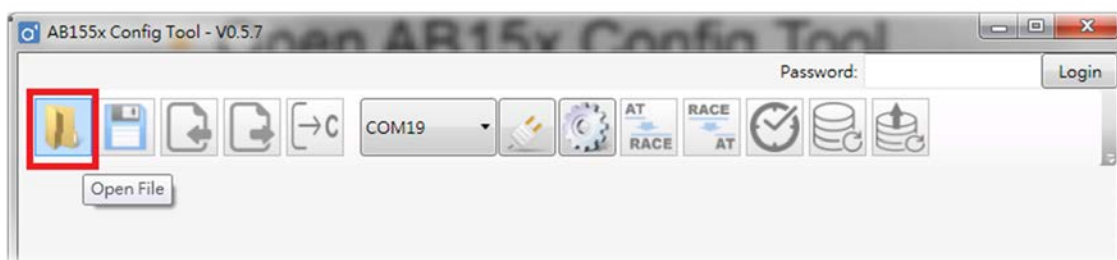


Figure 6. Step 1 of the Config Tool

- 2) Select VP section and VP language.

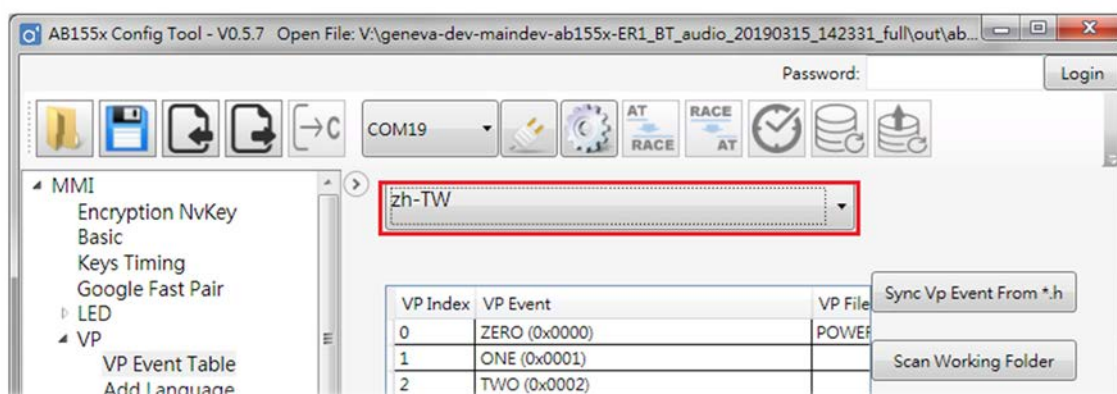


Figure 7. Step 2 of the Config Tool

- 3) Sync VP from *.h. The configuration file is in *config/mcu/project/<project_path>/inc/apps/config/apps_config_vp_index_list.h*. VP event will change as shown in Figure 8 and Figure 9.

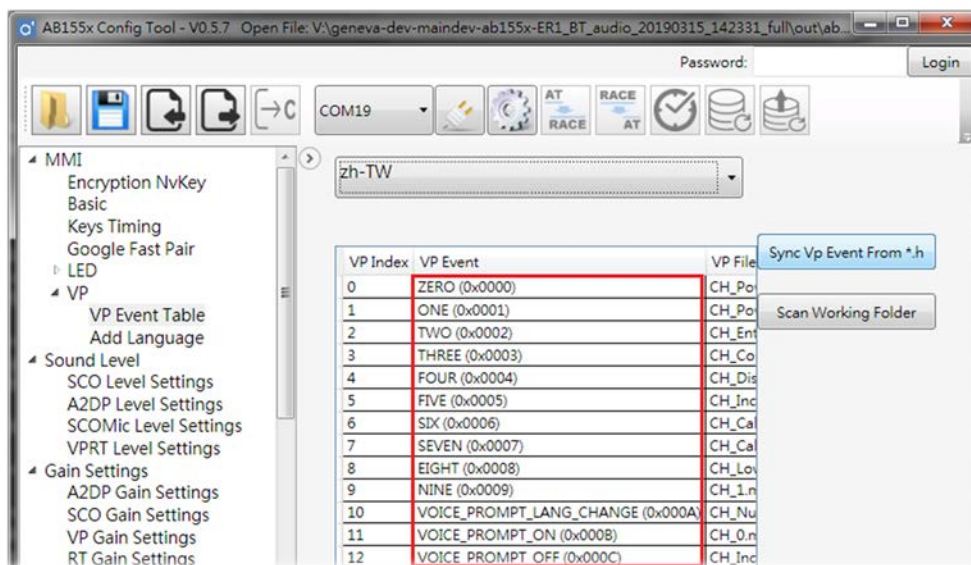


Figure 8. Step 3 of the Config Tool (before sync)

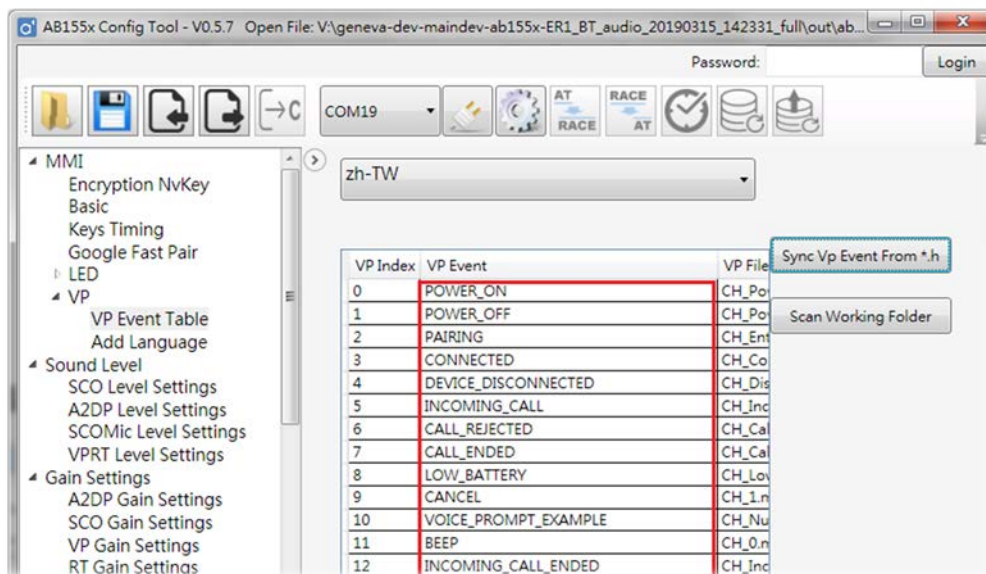


Figure 9. Step 3 of the Config Tool (after sync)

- 4) Sync VP from the work folder. When open AB158x config, the working folder is in ConfigTool folder as shown in Figure 10. The working folder contains voice prompt mp3 files which are stored in AB158x SDK by default.

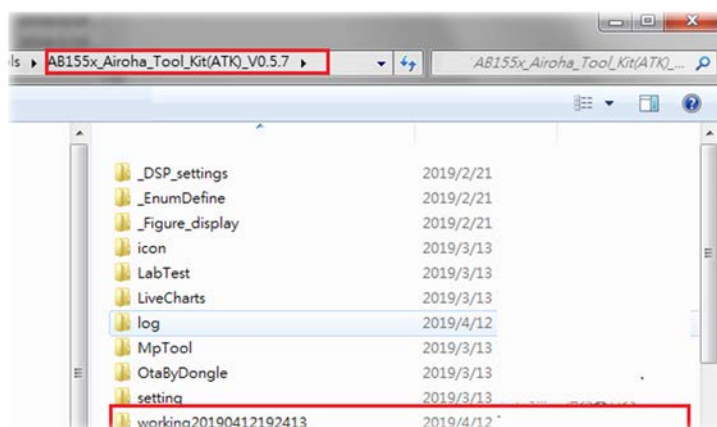


Figure 10. Step 4 of the Config Tool (default folder)

- 5) Copy the customized voice prompt files to the working folder. Please note that there is only support for mp3 files and the file names must be renamed according to the ENUM type in /mcu/project/<board>/apps/<project>/inc/apps/config/apps_config_vp_index_list.h. For example, VP_INDEX_POWER_ON is defined as index name of VP of power on, so the file must be renamed as POWER_ON.mp3.

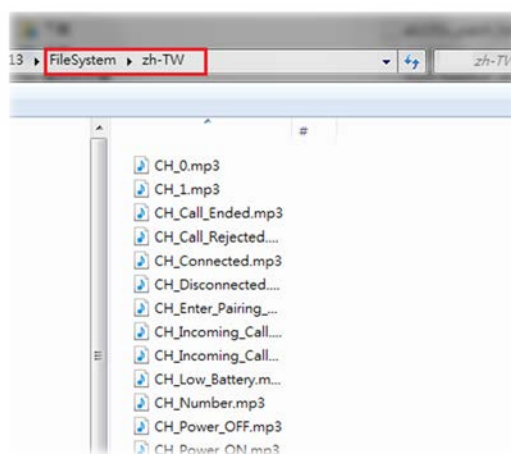


Figure 11. Step 5 of the Config Tool (user files)

- 6) Click sync working folder button, and double-click the VP index to add/remove the voice prompt files.

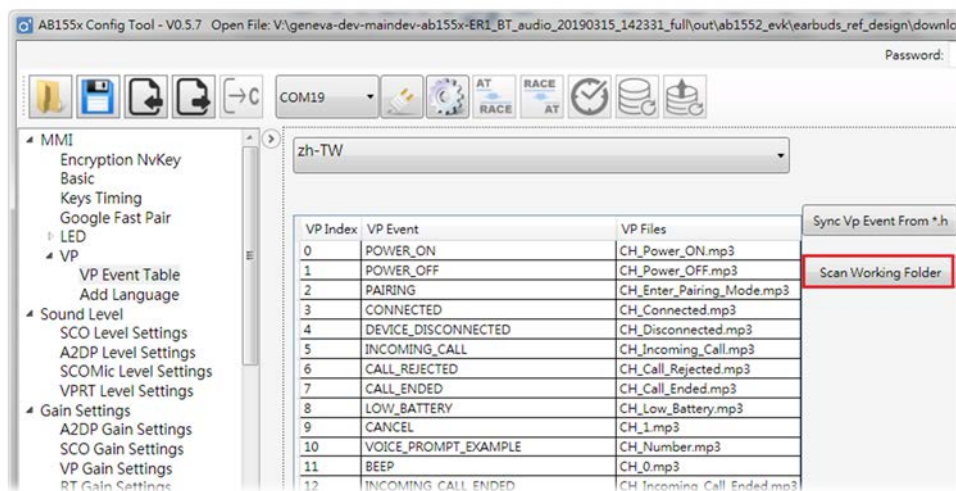


Figure 12. Step 6 of the Config Tool (scanning the working folder)

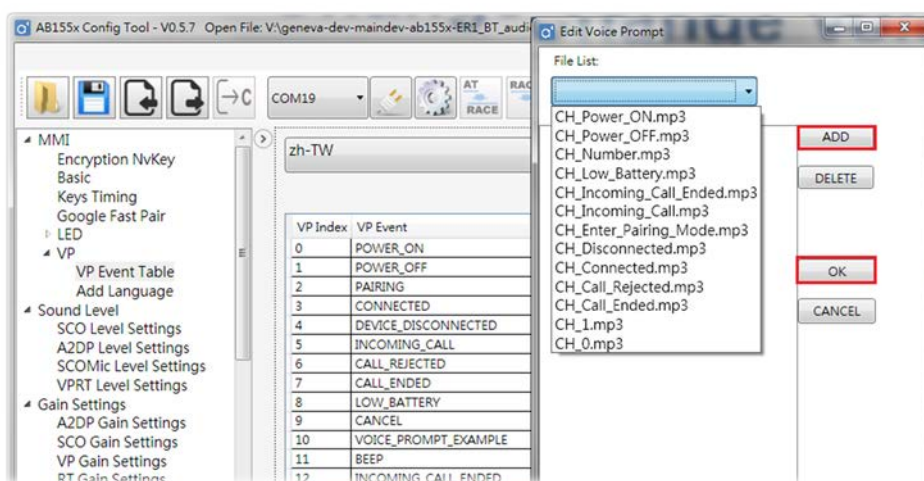


Figure 13. Step 6 of the Config Tool (adding VP)

- 7) When you finish adding/removing the VP files, you must click the ConfigTool save button to update *nvdn.bin* and *filesystem.bin*. The *nvdn.bin* and *filesystem.bin* will be updated in the folder `\mcu\project\<chip>\apps\earbuds_ref_design\config_bin\<board_type>`.

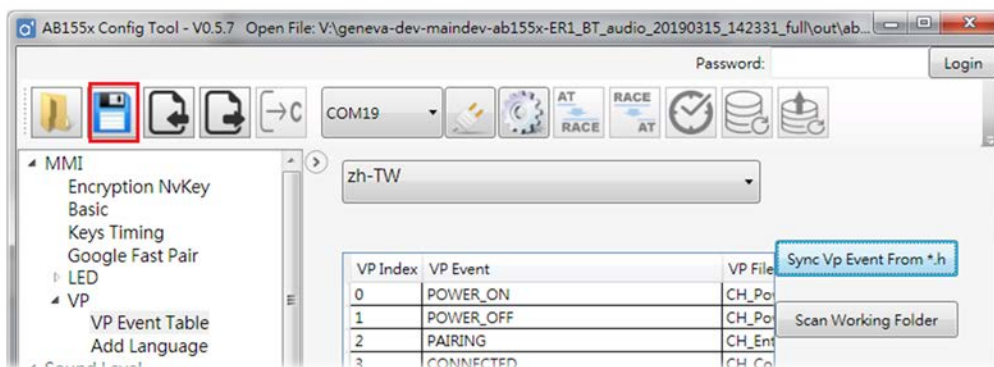


Figure 14. Step 7 of the Config Tool

Every time you build the load, the *nvdn.bin* and *filesystem.bin* will be copied to the out folder /out/<board_type>/earbuds_ref_design/download. If you do not want to build code after you have changed the *nvdn.bin* or *filesystem.bin*, you can copy the two files manually before downloading.

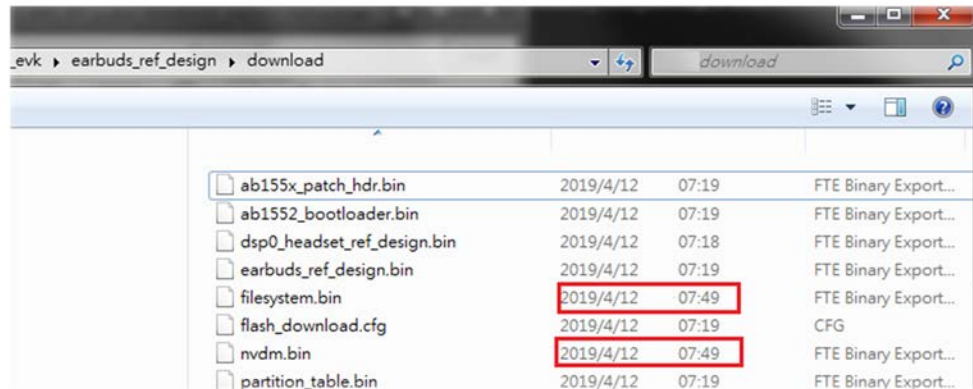


Figure 15. Binary files in build out folder

Please refer to the document AB155x_AM255x_Config_Tool_Users_Guide or AB157x_AB158x_Series_Config_Tool_Users_Guide for more details.

4.2.2. Call voice prompt in Code

The functions to play a voice prompt are as follows:

- `voice_prompt_status_t voice_prompt_play(voice_prompt_param_t *vp, uint16_t *play_id);`

Please refer to the file /mcu/project/<project_path>/src/apps/vp/voice_prompt_api.h to get more information.

4.3. LED pattern

LED pattern configurations are supported to change the LED flash behavior, including ON/OFF, frequency, repeat time and others.

4.3.1. Change LED patterns

- 1) Use ConfigTool to open the folder which contains *nvdn.bin* and *filesystem.bin*.
- 2) Click the button and select the file mcu/project/<chip>/apps/<project>/inc/apps/config/apps_config_led_index_list.h. The number of max LED style number is depends on the file.

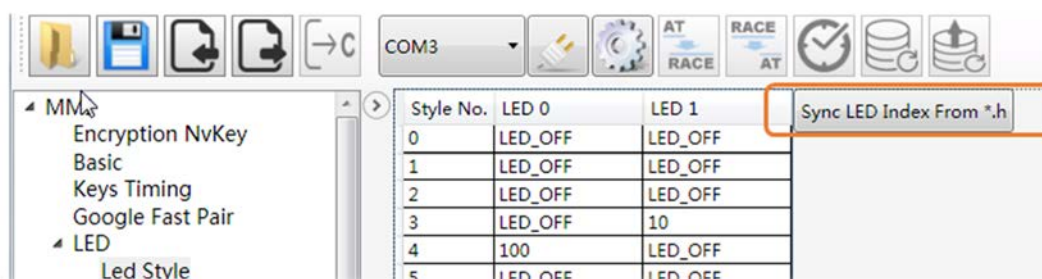


Figure 16. Step 2 of the LED pattern config

- 3) Increase or decrease the ENUM type defined in `/mcu/project/<board>/apps/<project>/src/apps/config/apps_config_led_index_list.h` to add or remove LED pattern.
- 4) Click to fine tune the LED pattern of one line.

Style No.	LED 0	LED 1	Sync LED Index From *.h
0	LED_OFF	LED_OFF	
1	LED_OFF	LED_OFF	
2	LED_OFF	LED_OFF	
3	LED_OFF	10	

Figure 17. Step 4 of the LED pattern config (select item)

LED 0
LED 1

Information

Led Time Unit: (ms)

T0:

T1:

T2:

T3:

Repeat times(T1、T2):

Loop For Extend Repeat times:

LED Brightness:

LED Pattern: LED_OFF

Figure 18. Step 4 of the LED pattern config (adjust parameters)

Figure 19 shows the parameters those should be set when LED patterns are changed.

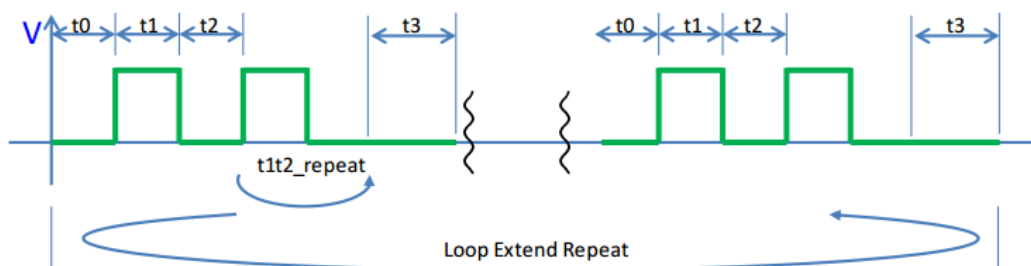


Figure 19. Parameters of LED patterns

Please refer to the document AB155x_AM255x_Config_Tool_Users_Guide or AB157x_AB158x_Series_Config_Tool_Users_Guide for more details.

4.3.2. Call LED in code

Here are the functions to set the foreground and background LED patterns.

- *bool apps_config_set_foreground_led_pattern(uint8_t index, uint16_t timeout):* Index is the LED style number in ConfigTool. Timeout is the active timeout of the foreground pattern.
- *bool apps_config_set_background_led_pattern(uint8_t index):* Index is the LED style number in ConfigTool.

Please refer to the file /mcu/project/<project_path>/src/apps/config/apps_config_led_manager.h to get more information.

4.4. Modify AB15xx MMI key events

The following procedure shows how to modify the MMI Key Events.

- (1) Use EPT Tool to generate the Pinmux configurations you need to add a key action.
- (2) Use Airoha Tool Kit to config the key timings of your key actions, such as the duration of a long press.
- (3) Finally, you must change/add the mapping table of key action as in this chapter.

4.4.1. EPT tool

Airoha Easy PinMux Tool (EPT) is a convenient and user-friendly graphical user interface (GUI) to configure pin multiplexor (PinMux) and supported driver settings for Airoha chipsets. The tool provides modes and options for each PinMux and enables customized settings for input and output (I/O) characteristics according to design requirements. When configured, all settings can be saved as a workspace file that can be reloaded to apply the preconfigured tool settings. The results can also be output as C header and source files.

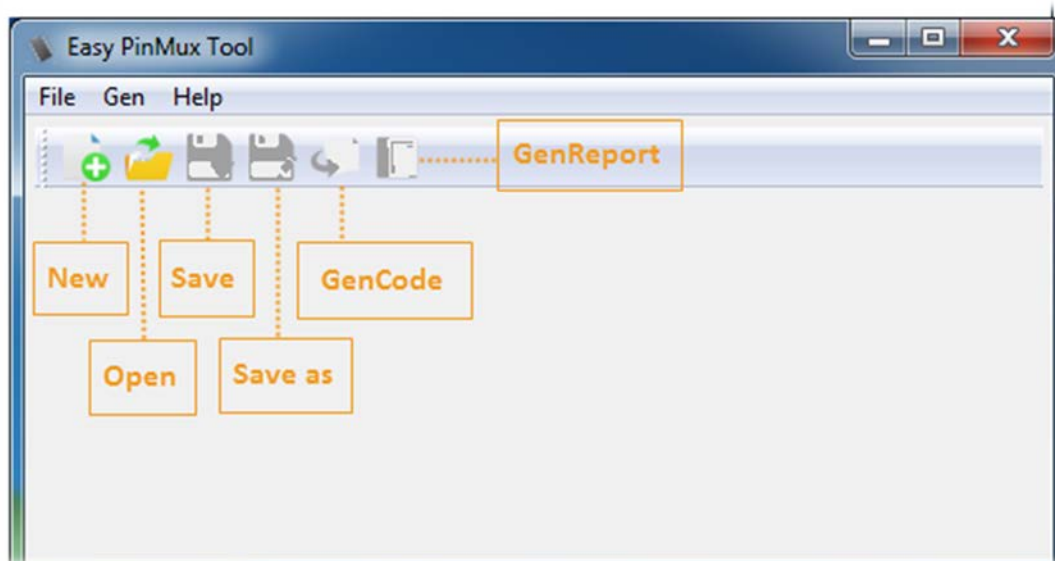


Figure 20. EPT tool (tool button)

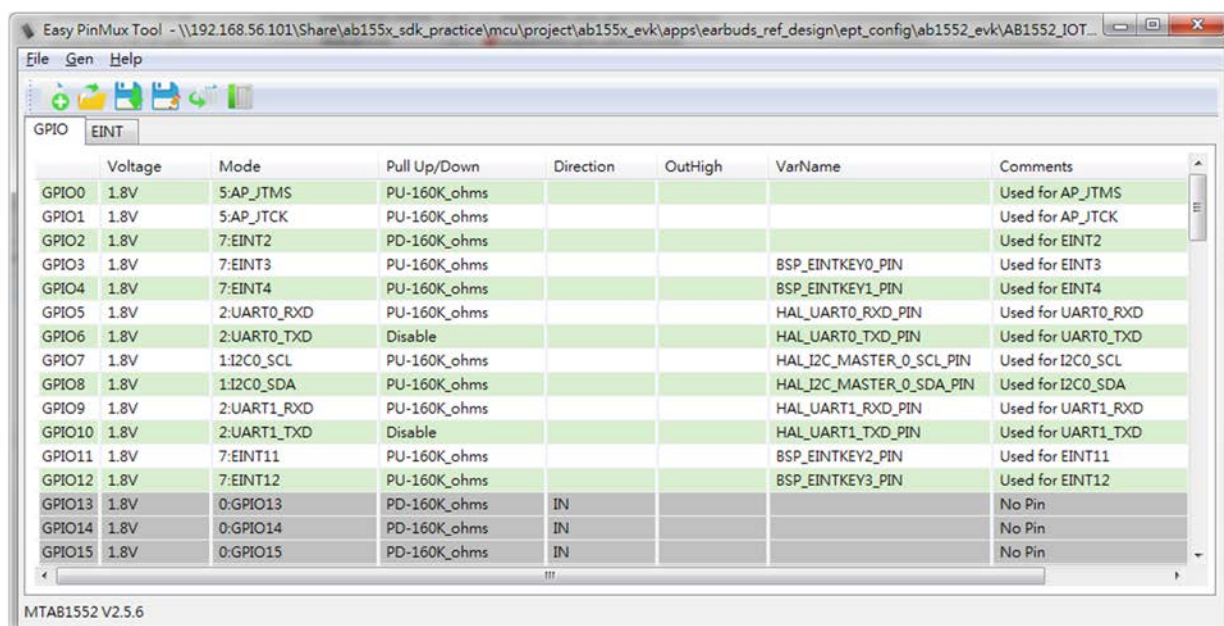


Figure 21. EPT tool (config)

Generate file and copy to your project. The copy destination is ept\output\<chip>\inc =>
 <sdk_root>\mcu\project\<board>\apps\<project>\inc and ept\output\<chip>\src =>
 <sdk_root>\mcu\project\<board>\apps\<project>\src. The work steps is as Figure 22.

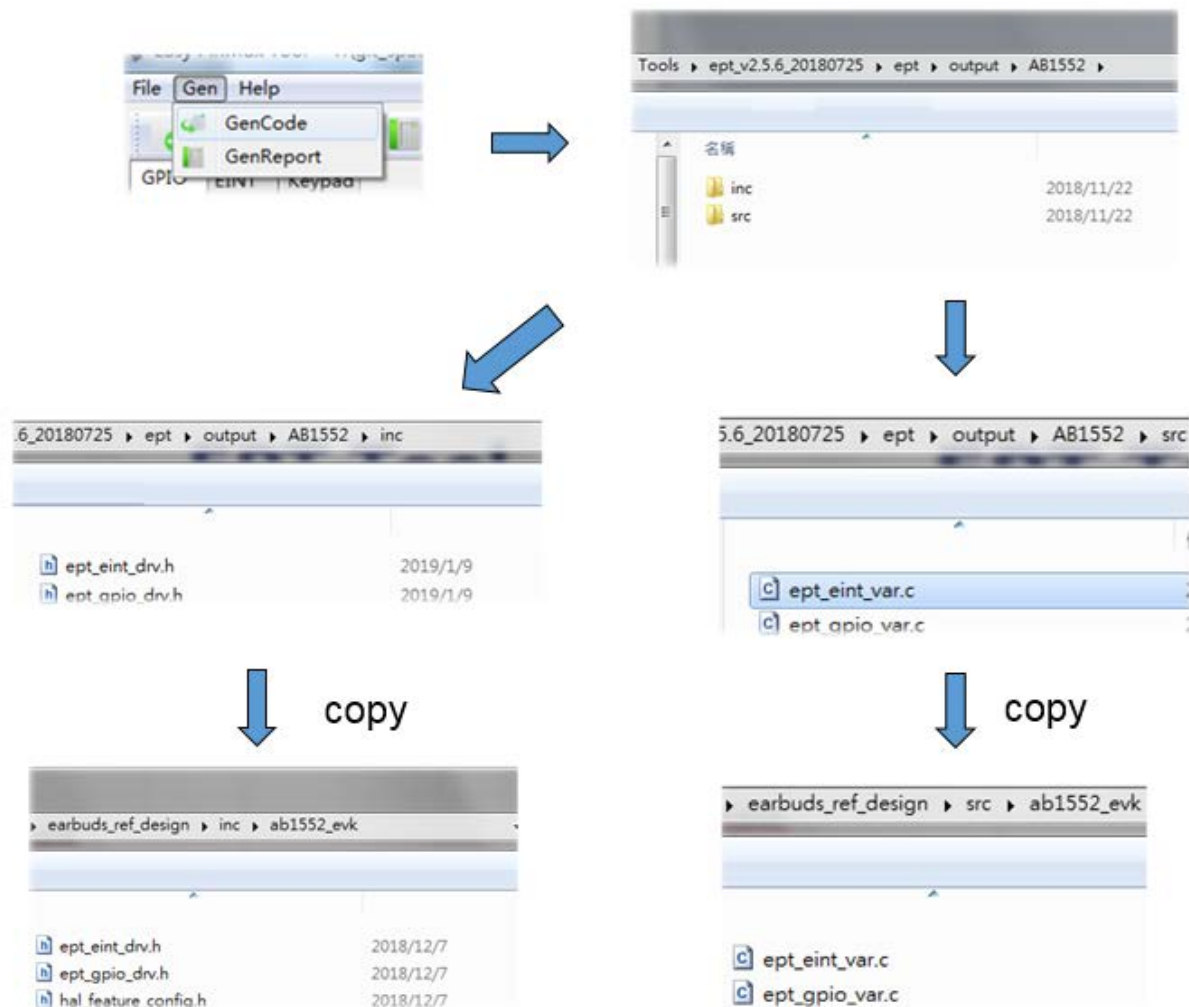


Figure 22. Work flow for the EPT tool

Please refer to the document Easy_PinMux_Tool_Users_Guide for more details.

4.4.2. Airoha Tool Kit

Use Airoha Tool Kit to configure key timing as shown in Figure 23.

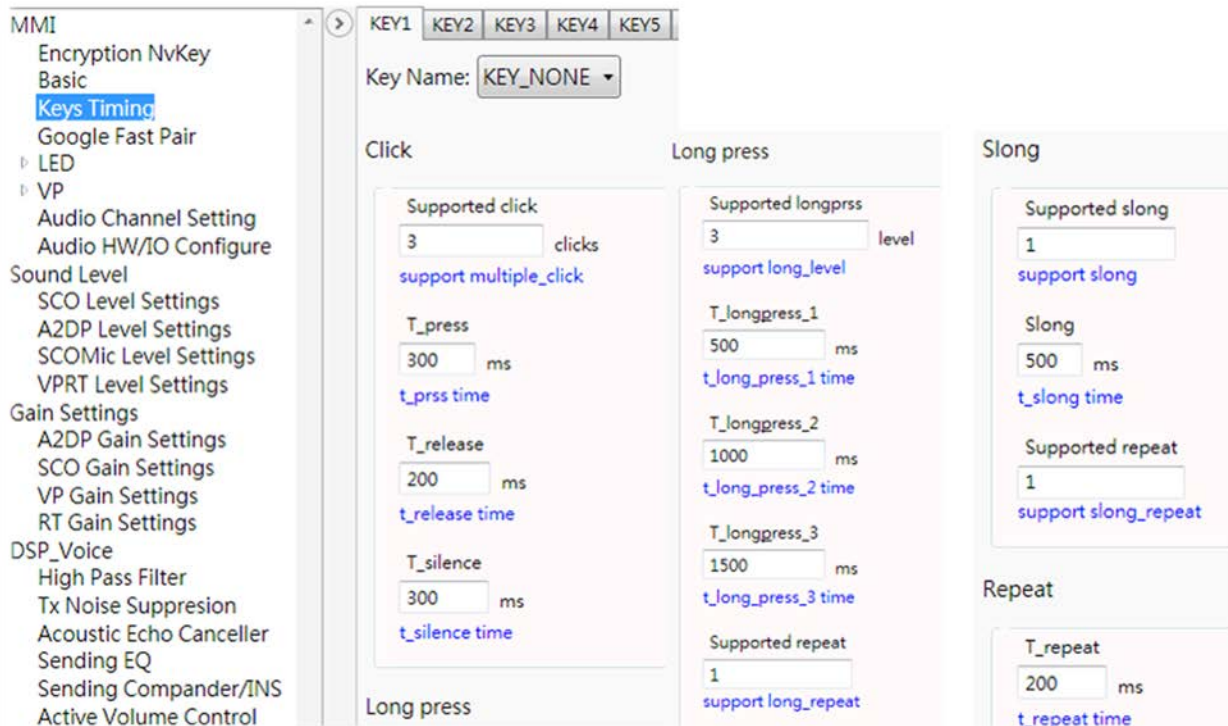


Figure 23. Airoha Tool Kit timing config

Please refer to the document of Airoha Tool Kit for more details.

4.4.3. AB15xx key event

Customers are able to change/add mapping table of Key Action. The mapping table is declared in /mcu/project/<project_path>/src/<board_type>/customerized_key_config.c as showed in Figure 24. The logic of key mapping can be simply described as the action is decided by Key ID, Key Event and current status.

```
const apps_config_key_event_map_t temp_key_short_click_configs[] = {
    {
        DEVICE_KEY_POWER,
        KEY_ACPCALL,
        (1 << APP_HFP_INCOMING) | (1 << APP_HFP_CAIMG)
    },
    {
        DEVICE_KEY_POWER,
        KEY_AVRCP_PLAY,
        (1 << APP_CONNECTED)
    }
}
```

Figure 24. Mapping table for the key action

Add new action means add new logic. The new key actions can be added in file /mcu/project/<project_path>/inc/apps/config/apps_config_event_list.h. And the app code must be changed to support the new feature.

MMI state is defined in `mcu/project/<chip>/apps/earbuds_ref_design/inc/apps/config/apps_config_state_list.h`. Customers must study UI shell and the usage of `APPS_EVENTS_INTERACTION_UPDATE_MMI_STATE` event in APPs in order to add MMI states.

5. FAQ

5.1.1. How to change BLE advertising data?

The BLE device name is defined in function `bt_customer_config_get_ble_device_name()` in file `mcu/project/<project>/src/bt_customer_config.c`. And you need to read the `bt_app_common_advting_start()` in file `mcu/project/<board>/apps/<project>/src/bt_app_common.c` to get the information of the other data in BLE advertising.

5.1.2. How do Agent and Partner communicate?

Agent and Partner communicate with each other by MCSync packets.

- Function `bt_sink_srv_send_action()` is an SDK API for sending MCSync packet to each other.
- Function `apps_aws_sync_event_send()` is a shortcut of the API `bt_sink_srv_send_action()` to send simple data.

For example, to do a role handover triggered by a key:

1. Add `KEY_ROLE_SWITCH_TO_AGENT` in `apps_config_event_list.h`.
2. Parse `BT_SINK_SRV_EVENT_AWS_MCE_PACKET_RECEIVED_IND` in function `homescreen_app_bt_sink_event_proc()`.
3. Decode event group with `EVENT_GROUP_UI_SHELL_KEY` and `event_id` with `KEY_ROLE_SWITCH_TO_AGENT`.

5.1.3. What is a NVDM reserve list?

There are two NVDM reserve lists in “Airoha IoT SDK for BT Audio” in path `mcu/project/<board>/apps/<project>/inc/`. The list in `nvdm_config.h` is for FOTA upgrade, and the other in `nvdm_config_factory_reset.h` is for factory reset. After a FOTA upgrade or doing factory reset, all NVDM items except those in the reserve lists will be cleared.

`nvdm.bin` can be modified according to document `AB155x_AM255x_Config_Tool_Users_Guide` or `AB157x_AB158x_Series_Config_Tool_Users_Guide`, and is not upgraded when user does FOTA because some important information (e.g. BT address) is stored in `nvdm.bin`. After setting the BT address in factory, the `nvdm.bin` should not be upgraded.

6. Appendix

Table 5. Voice Prompt Index

Condition	VP index
System power on and device is not charging	VP_INDEX_POWER_ON
Take out from charger case	VP_INDEX_POWER_ON
Battery is too low to power off	VP_INDEX_POWER_OFF
Press key to power off	VP_INDEX_POWER_OFF
Wait connection too long to sleep	VP_INDEX_POWER_OFF
Device is enter pairing mode or air pairing	VP_INDEX_PAIRING
Device is connected by smartphone	VP_INDEX_CONNECTED
Device is disconnected from smartphone	VP_INDEX_DEVICE_DISCONNECTED
Incoming call	VP_INDEX_INCOMING_CALL
Reject call by pressing key on earbuds	VP_INDEX_CALL_REJECTED
Active call is ended	VP_INDEX_CALL_ENDED
Battery capacity is low	VP_INDEX_LOW_BATTERY
Fail to response a key action	VP_INDEX_FAILED
Press key long enough to trigger voice assistant	VP_INDEX_PRESS
FOTA finish successfully	VP_INDEX_SUCCEEDED
Received find me request from smartphone	VP_INDEX_DOORBELL

Table 6. Foreground LED Patterns

Event	LED index	Timeout
System power on and device is not charging	LED_INDEX_POWER_ON	3s
Take out from charger case	LED_INDEX_POWER_ON	3s
Battery is too low to power off	LED_INDEX_POWER_OFF	3s
Press key to power off	LED_INDEX_POWER_OFF	3s
Wait connection too long to sleep	LED_INDEX_POWER_OFF	3s
Charging full	LED_INDEX_CHARGING_FULL	5s

Event	LED index	Timeout
Start FOTA	LED_INDEX_FOTA_START	3s
FOTA is interrupted	LED_INDEX_FOTA_CANCELLED	3s
Start air pairing	LED_INDEX_AIR_PAIRING	30s
Air pairing is success	LED_INDEX_AIR_PAIRING_SUCCESS	3s
Air pairing is failed	LED_INDEX_AIR_PAIRING_FAIL	3s

Table 7. Background LED Patterns

State	LED index
Battery charging but not charging full	LED_INDEX_CHARGING
Battery is low	LED_INDEX_LOW_BATTERY
Find me	LED_INDEX_FIND_ME
Incoming call	LED_INDEX_INCOMING_CALL
Outgoing call	LED_INDEX_OUTGOING_CALL
Call active	LED_INDEX_CALL_ACTIVE
Hold call	LED_INDEX_HOLD_CALL
Pairing mode	LED_INDEX_CONNECTABLE
Disconnected and not in pairing mode	LED_INDEX_DISCONNECTED