



# MPLAB Harmony Audio Help

MPLAB Harmony Integrated Software Framework

# Audio Overview

This topic provides a brief overview of audio and Harmony support for audio.

## Description

This distribution package contains a variety of audio-related firmware projects that demonstrate the capabilities of the MPLAB Harmony audio offerings. Each project describes its hardware setup and requirements.

This package also contains drivers for hardware codecs that can be connected to development boards, such as the WM8904 Codec Daughterboard.

Finally, it contains a BSP Audio Template that can be used to make configuring a new audio project a matter of just a few mouse clicks.

Prior to using this demonstration, it is recommended to review the MPLAB Harmony Release Notes (`release_notes.md`) for any known issues. It is located in the `audio` folder.

The sample demonstration projects are in the `audio/apps` folder. The Codec Driver is in the `audio/driver` folder. The Audio Template is in the `audio/templates` folder.



**Important!** This repository only contains the files for the audio applications, drivers and templates.

Although you can build the applications standalone from within this repository, you will *not* be able to run the MHC or regenerate the code without the other Harmony repositories.

Please refer to the MPLAB Harmony Release Notes in the `audio` for the other Harmony repositories required to work with this one.

## Legal

Please review the Software License Agreement (`mplab_harmony_license.md`) prior to using MPLAB Harmony. It is the responsibility of the end-user to know and understand the software license agreement terms regarding the Microchip and third-party software that is provided in this installation. A copy of the agreement is available in the `audio` folder of your MPLAB Harmony installation.

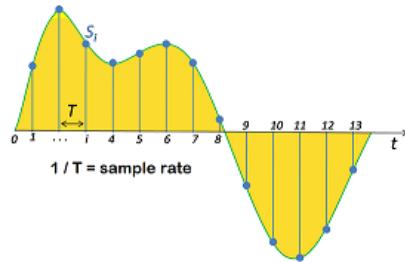
# Digital Audio Basics

This topic covers key concepts in digital audio.

## Description

If you are new to digital audio, this section provides definitions of basic concepts found in most discussions of digital audio.

Digital audio is sound that has been converted into digital form, by taking samples at a repeated rate (called the **sample rate** or **sampling rate**), at a particular resolution expressed as the number of bits per sample (called the **bit-depth**).



For example, audio stored on a compact disk (CD) is sampled at 44,100 samples/second, or 44.1 kHz, and saved as 16-bit signed samples. Other common sample rates are 8 kHz or 16 kHz for telephony-quality voice, 48 kHz for DVD audio, and 96 kHz for high-definition audio. The sample rate must be at least twice as fast as the highest frequency that is to be converted; therefore CD's have an upper frequency limit of 22.05 kHz. High-definition audio may also use 20, 24, or even 32-bits per sample. Low-quality voice may be sampled at only 8 bits per sample. Higher bit depths reduce the SNR (signal to noise ratio).

Changing from a lower sample rate to a higher one is called upsampling; changing from a higher sample rate to a lower one is called downsampling.

Sound is converted into digital using a analog to digital converter (ADC), connected to a microphone or other analog audio input, and converted from digital back to analog using a digital to analog converter (DAC) connected to an amplifier and then a speaker or pair of headphones.

After being sampled, digital sound may be stored in several formats. Some formats compress the audio to save space.

Compression can be either lossless, meaning the audio when uncompressed, will be exactly the same as the input; other formats may be lossy, meaning some of the original audio may be lost, but it will usually be sounds that are hard to hear. Lossy compression typically achieves much higher compression rates than lossless (lossy compressing down to 5% to 20% of the original size, compared to 50%-60% for lossless). Compression and decompression is done by software codecs.

#### Common Audio Formats

Format	Lossy?	Proprietary?	Comments
AAC (Advanced Audio Coding)	Yes	No	Designed as successor to MP3. Audio codecs must be licensed.
FLAC (Free Lossless Audio Codec)	Yes	No, open-source	
MP3	Yes	No	Was patented but patent has expired
Ogg Vorbis	Yes	No, open-source	
Opus	Yes	No, open-source	Low latency
PCM/WAV	No	No	Uncompressed linear PCM audio format used with CD's
WMA (Windows Media Audio)	No	Yes	

## I<sup>2</sup>S Audio

There are various digital audio interfaces, designed to connect components together, either on the same board or via cables between boards. The one that is most relevant for us is I<sup>2</sup>S (Inter-IC sound) protocol which specifies a specific interface commonly used to connect hardware codecs, DACs, Bluetooth modules, and MCUs on the same board. It is not intended to be used over cables.

An I<sup>2</sup>S interface consists of the the following signals:

- Word clock line, which runs at the sampling rate and also indicates left/right channel, often abbreviated as LRCLK
- Bit clock line, often abbreviated as BCLK. The bit clock pulses once for each discrete bit of data on the data lines.

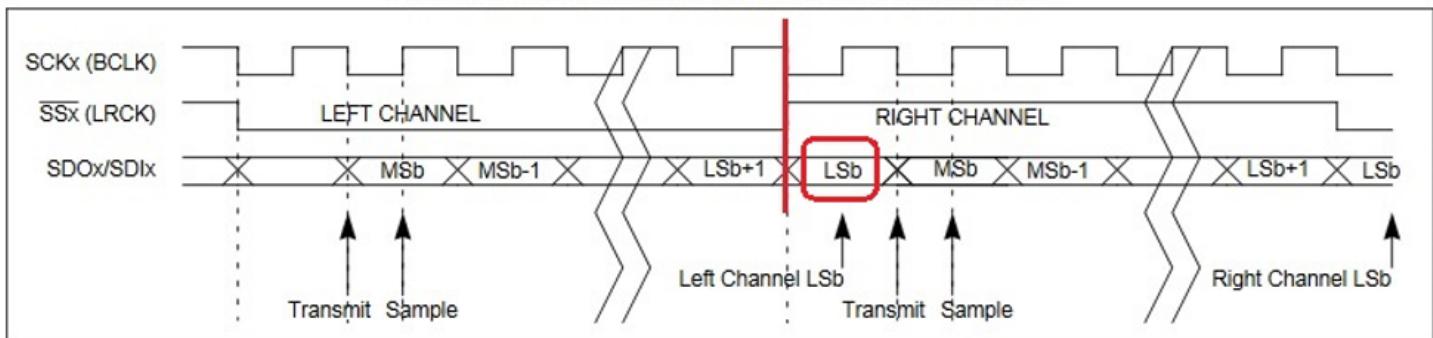
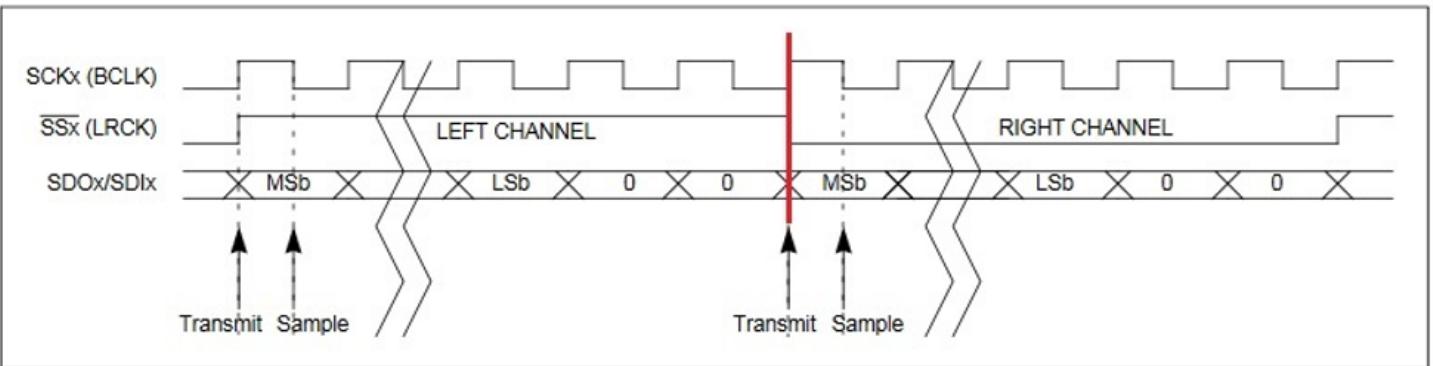
The bit clock rate = sample rate \* # of channels \* # of bits / channel

e.g. for CD audio, 44.1 kHz \* 2 channels (stereo) \* 16 bits/channel = 1.4112 MHz

- One or two serial data lines for input and output (ADCDAT and DACDAT)

Although not part of the standard, there is often a master clock (MCLK) typically running at 256 times the sample rate used for synchronization.

A typical codec may support both I<sup>2</sup>S format, and one or two variations (left-justified and/or right justified):

**I<sup>2</sup>S with 16-bit Data/Channel or 32-bit Data/Channel****Left-Justified with 16/24-bit Data and 32-bit Channel**

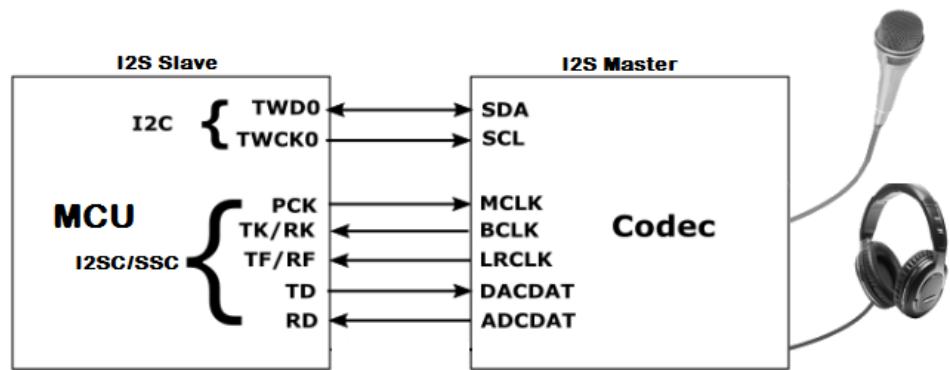
In I<sup>2</sup>S format, as shown in the top half of the figure above, LRCLK is low for the left channel and high for the right channel. The most-significant bit (MSb) of the left channel data starts one bit clock (BCLK) late, such that the least significant bit (LSb) is actually in the right channel side.

In Left-Justified format, as shown in bottom half of the figure above, LRCLK is high for the left channel, and low for the right channel, and the most-significant bit (MSb) is lined up with the LRCLK and does not spill over into the opposite channel.

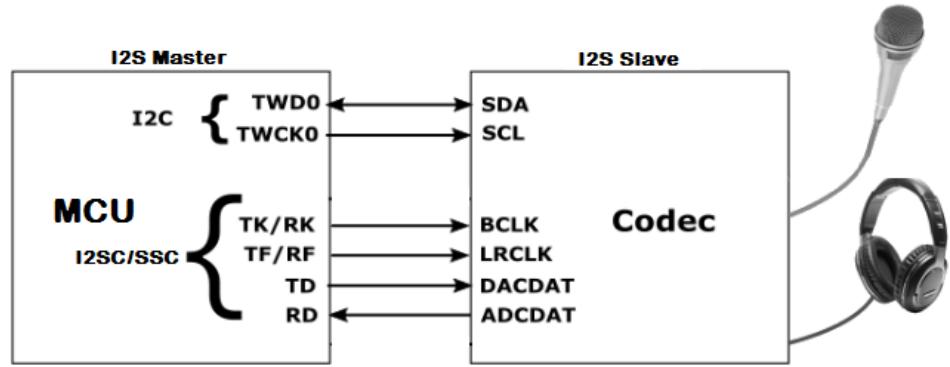
Below is a oscilloscope photo showing the LRCLK in yellow, and data in blue. Only the left channel has audio. The overlap in the I<sup>2</sup>S format is clearly visible, as well as the 16 individual data bits.



A codec or Bluetooth module can act as a Master, in which it generates the I<sup>2</sup>S clocks BCLK and LRCLK and sends them to the MCU (with the MCU providing a Master Clock):



If the MCU generates the I<sup>2</sup>S clocks BCLK and LRCLK, the codec or Bluetooth module is the Slave::

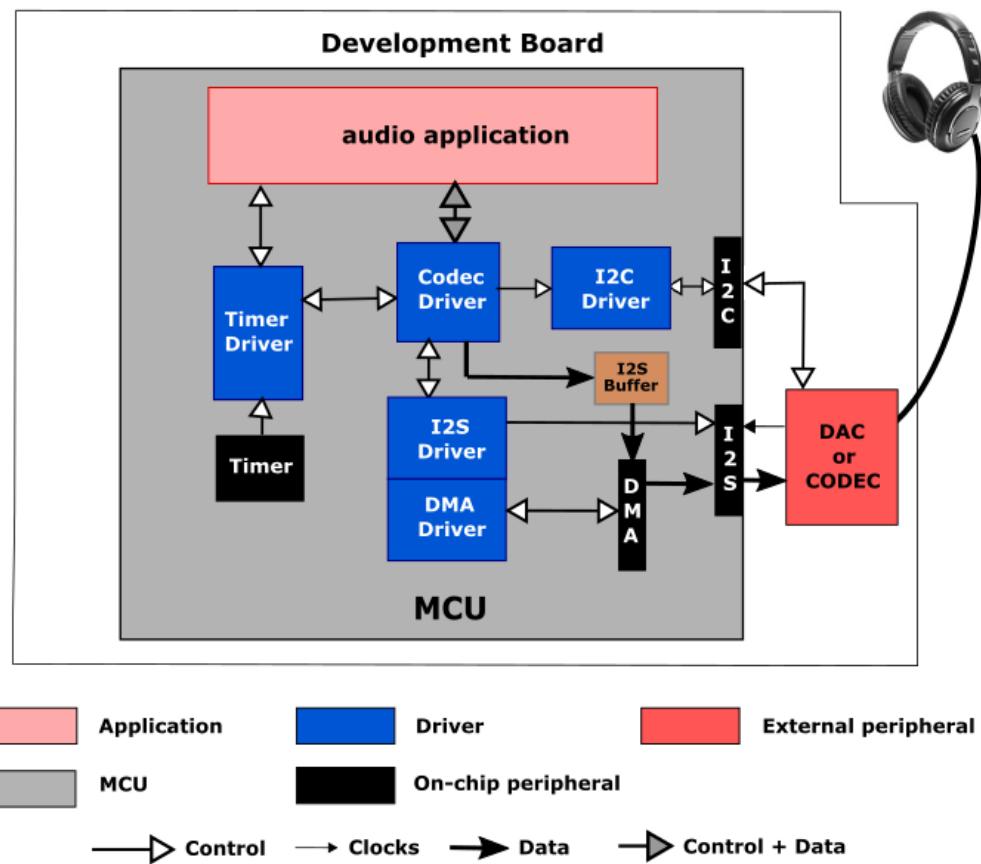


## Digital Audio in Harmony

This topic describes how digital audio is implemented in Harmony.

### Description

Audio projects in Harmony consist of an application, plus associated drivers and peripheral libraries (PLIBs). Projects using Harmony audio typically connect to either a hardware codec or DAC external to the MCU, using a I<sup>2</sup>S interface for audio. Some projects may also make use of USB.



The block diagram above depicts a generic audio application that sends audio to a hardware codec or DAC connected to a pair of headphones.

The application interfaces directly with a Codec Driver and a Timer. The Codec Driver in turn interfaces with an I<sup>2</sup>S Driver, and in this case, an I<sup>2</sup>C Driver which sends commands to and receives status from the DAC or codec via the I<sup>2</sup>C/TWIHS PLIB. In other instances an SPI interface might be used.

The I<sup>2</sup>S Driver interfaces with an I<sup>2</sup>S-capable PLIB, which may be implemented using an SPI, SPI, or I<sup>2</sup>SC hardware module depending on the MCU.

The I<sup>2</sup>S Driver also uses DMA to transfer audio from the application's audio buffer to the I<sup>2</sup>S-capable peripheral.

## Example Audio Projects

Example projects showing Harmony audio in action.

### Description

#### *The audio\_enc Demonstration*

The audio\_enc (encoder) application records and encodes PCM audio as wave (.wav) files on a mass storage device (e.g. thumb drive) connected to the USB Host port. Playback is an optional feature. It uses the I<sup>2</sup>S Driver, I<sup>2</sup>C Driver, codec driver (e.g. WM8904), I<sup>2</sup>S peripheral (e.g. SSC), DMA, Timer and USB library. A FreeRTOS version is also available.

#### *The audio\_player\_basic Demonstration*

The audio\_player\_basic application scans a mass storage device (e.g. thumb drive) connected to the USB Host port for wave (.wav) files, and then plays them out one by one through a codec. It uses the I<sup>2</sup>S Driver, I<sup>2</sup>C Driver, codec driver (e.g. WM8904), I<sup>2</sup>S peripheral (e.g. SSC), DMA, Timer and USB library.

#### *The audio\_signal\_generator Demonstration*

The audio\_tone application sends out generated audio (sine, square, sawtooth and triangle waveforms) with volume and frequency modifiable through a touch screendisplay. It uses the I<sup>2</sup>S Driver, I<sup>2</sup>C Driver, codec driver (e.g. WM8904), I<sup>2</sup>S peripheral (e.g. SSC), DMA and Timer.

***The audio\_tone Demonstration***

The audio\_tone application sends out generated audio waveforms (sine tone) with volume and frequency modifiable through the on-board push button. It uses the I2S Driver, I2C Driver, codec driver (e.g. WM8904), I2S peripheral (e.g. SSC or I2SC), DMA and Timer. A FreeRTOS version is also available.

***The audio\_tone\_linkeddma Demonstration***

The audio\_tone\_linkeddma application sends out generated audio waveforms (sine tone) with volume and frequency modifiable through the on-board push button, using the linked DMA feature of the MCU (where available). It uses the I2S Driver, I2C Driver, codec driver (e.g. WM8904), I2S peripheral (e.g. SSC or I2SC), DMA and Timer. Linked DMA allows the DMA to process multiple buffers sequentially, without MCU intervention.

***The microphone\_loopback Demonstration***

The microphone\_loopback application receives audio data from the microphone input on a codec, and then sends this same audio data back out through the codec to a pair of headphones after a delay. The volume and delay are configurable using the on-board pushbutton or touch screen display. It uses the I2S Driver, I2C Driver, codec driver (e.g. WM8904), I2S peripheral (e.g. SSC or I2SC), DMA and Timer. A FreeRTOS version is also available.

***The usb\_speaker Demonstration***

The usb\_speaker application acts as a USB device, playing streaming audio from a USB host such as a PC. It uses the I2S Driver, I2C Driver, codec driver (e.g. WM8904), I2S peripheral (e.g. SSC), DMA and Timer. A FreeRTOS version is also available.

# Audio Demonstrations

This section provides information on the Audio Demonstrations provided in your installation of MPLAB Harmony.

## Introduction

MPLAB Harmony Audio Demonstrations Help.

## Description

This help file contains instructions and associated information about MPLAB Harmony Audio demonstration applications, which are contained in the MPLAB Harmony Library distribution.

## Demonstrations

This topic provides instructions about how to run the demonstration applications.

## audio\_enc

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

## Description

The audio encoder (audio\_enc) application configures the SAM E70 Xplained Ultra development board to be in USB Host Mass Storage Device (MSD) mode. The application supports read/write from/to the FAT file system. When a mass storage device is connected to the development board via its target USB port, the device is mounted. After the MSD is mounted, the application waits for a short button press (< 1 sec) to start recording data from the mic input on the WM8904 Audio Codec Module. This recording will continue until another short press is detected signaling to stop recording. The recorded data is then PCM encoded and packed into a .wav container file and saved on the MSD. The app then waits to playback the last recorded file or encode another file.

All encodings are at 16K sample rate, stereo, and 16 bit depth. The name of the encoded file will be created in according to the following (enc16K16b<000-999>.wav). A file will not be written over if it already exists. If a file is found to be already on the MSD, the numeric part of the file name will increment once until an unused file name is found. If trying to playback the last encoded file but there has been no file encoded yet, both LEDs will flash and the app will go back to waiting to start encoding a file. If there is a file available to be played, the app will read the .wav file data and write it to the codec for playback.

Command and control to the codec is done through an I2C driver. Data to the codec driver is sent through I2SC via I2S Driver and the output will be audible through the headphone output jack of the WM8904 Audio Codec Module connected to the SAM E70 Xplained Ultra board. The below architecture diagram depicts a representation of the application.

The current development board, SAM E70 Xplained Ultra, supplies one button and two LEDs for control and status feedback. LED 1 is amber and LED 2 is green. The application currently only supports PCM encoding and playback to and from a .wav file container.

Supported audio files are as represented in the table below.

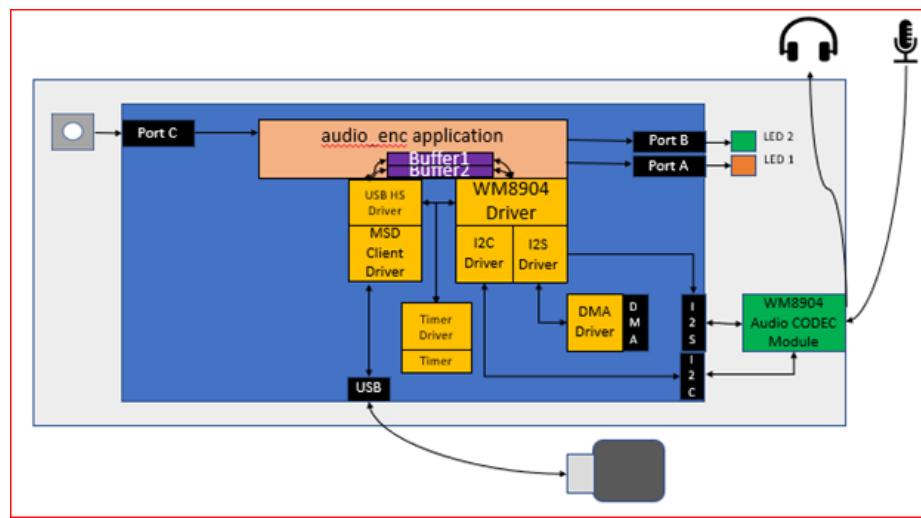
Audio Format	Sample Rate (kHz)	Description
PCM	16	PCM (Pulse Code Modulation) is an uncompressed format. The digital data is a direct representation of the analog audio waveform. The container for the data will be a WAVE file (.wav) format. It is the native file format used by Microsoft Windows for storing digital audio data.

## Architecture

The audio encoder (audio\_enc) application uses the MPLAB Harmony Configurator to setup the USB Host, FS, Codec, and other items in order to read the music files on a USB MSD drive and play it back on the WM8904 Codec Module. It scans WAV (PCM)

format files on mounted FAT USB thumb drive and streams audio through WM8904 Audio Codec to a speaker. In the application, the number of audio output buffers can always set to be more than two to enhance the audio quality. And, the size of input buffer in this application is chosen to be able to handle all data supported. The following figure shows the architecture for the demonstration.

**Architecture Block Diagram**

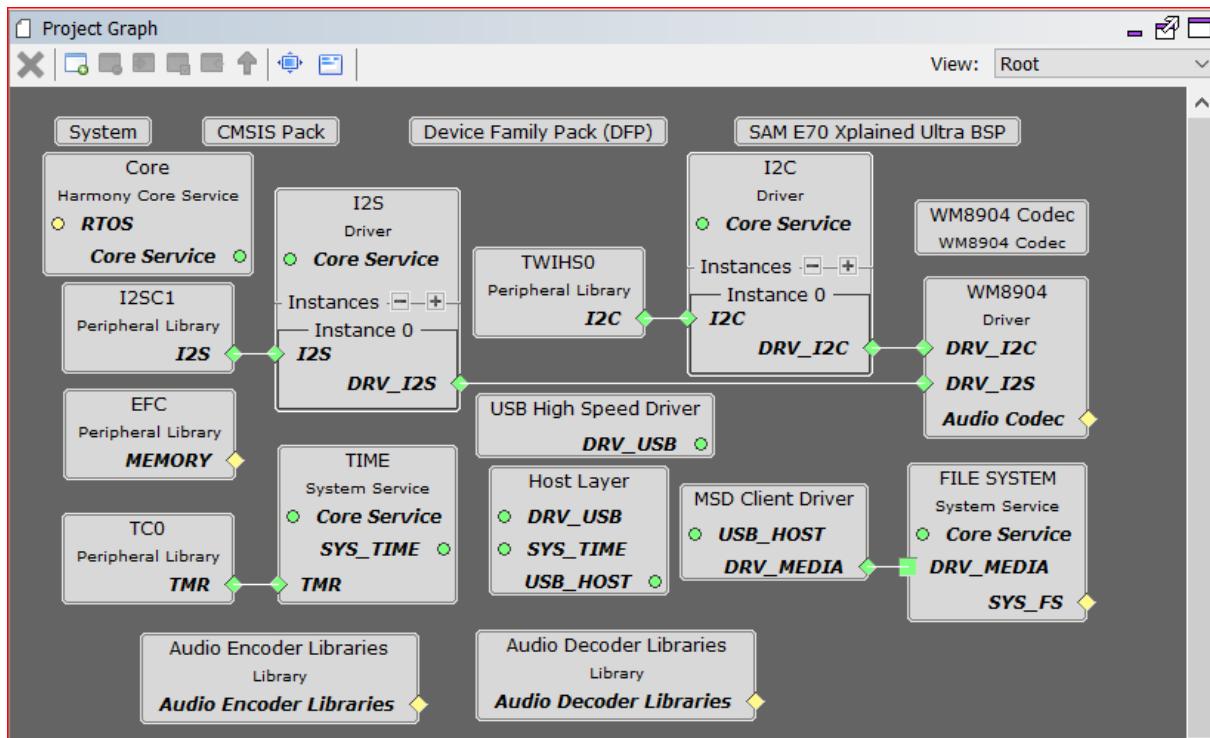


## Demonstration Features

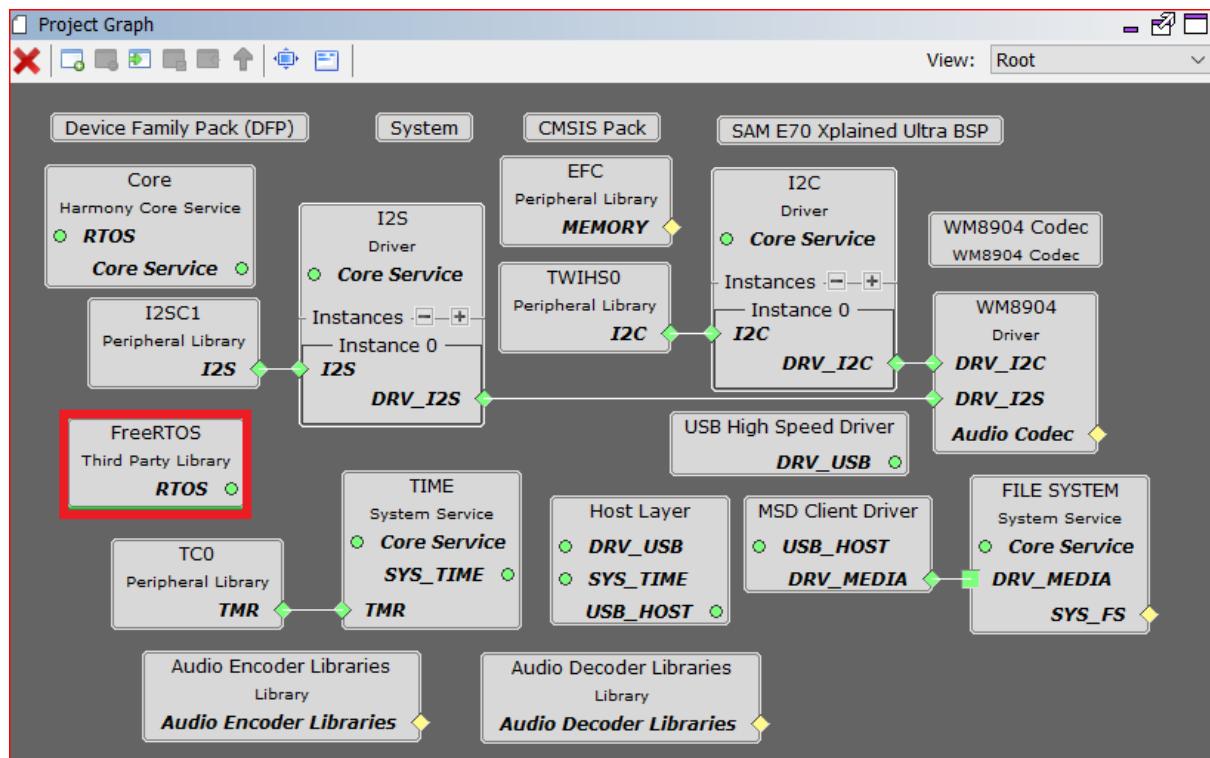
- USB MSD Host Client Driver (see H3 USB MSD Host Client Driver Library)
- FAT File System (see H3 File System Service Library)
- Audio real-time buffer handling
- WM8904 Codec Driver (see H3 CODEC Driver Libraries)
- I2S usage in audio system (see H3 I2S Driver Library Help)
- DMA (see H3 DMA area)
- Timer (see H3 Timer area)
- GPIO Control (see H3 GPIO area)

## Harmony Configuration

1. Add BSP->SAM E70 Xplained Ultra BSP
  2. Add Audio->Templates->WM8904 Codec
    - Yes to all popups
    - Modify WM8904 Codec from SSC to I2SC
      - Yes to all popups
  3. Add Libraries->USB->Host Stack->MSD Client Driver
    - a. Yes to all popups
  4. Add Harmony->System Services->FILE SYSTEM
  5. Add Harmony->Audio->Decoder->AudioDecoderLibraries
  6. Add Harmony->Audio->Encoder->AudioEncoderLibraries
  7. Remove FreeRTOS if Bare Metal version
  8. Connect MSD Client Driver: DRV\_MEDIA to FILE SYSTEM: DRV\_MEDIA
- After reorganization, your graph should look similar to the following:



If using FreeRTOS, your diagram will be slightly different. You will see an additional block for FreeRTOS as shown below.

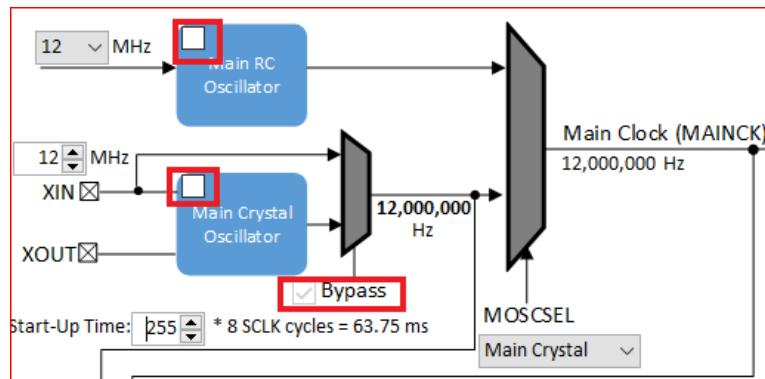


## Tools Setup Differences

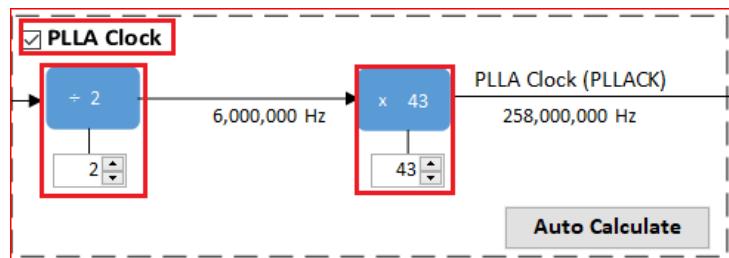
The default configuration should be correct for the majority of the app. There following configurations will need to be changed in order for proper operations.

### MPLAB Harmony Configurator: Tools->Clock Configuration

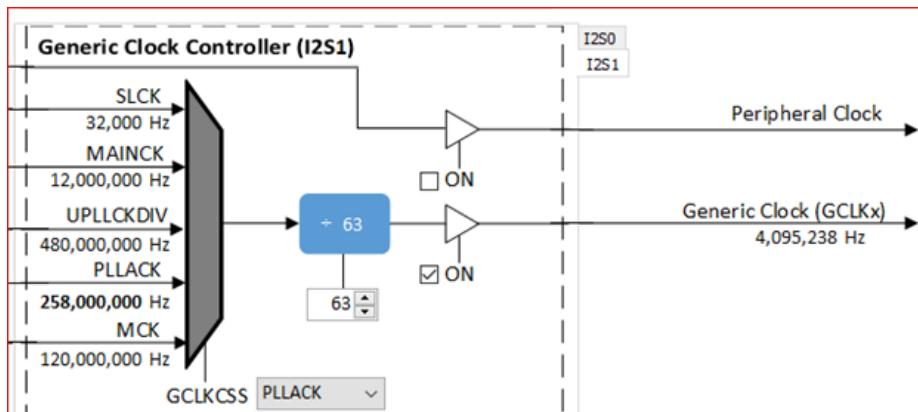
Uncheck the Main RC Oscillator and check the "Bypass" for the Main Crystal Oscillator. When the Bypass is checked, it will cause the Main Crystal Oscillator to become unchecked.



Enable the PLLA Clock output.

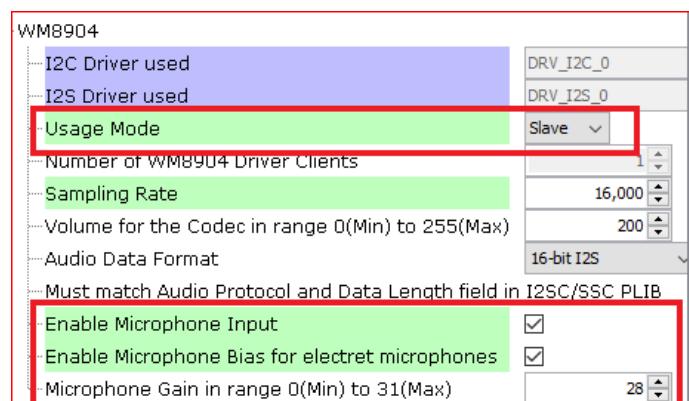


Enable clocking for the I2S1.



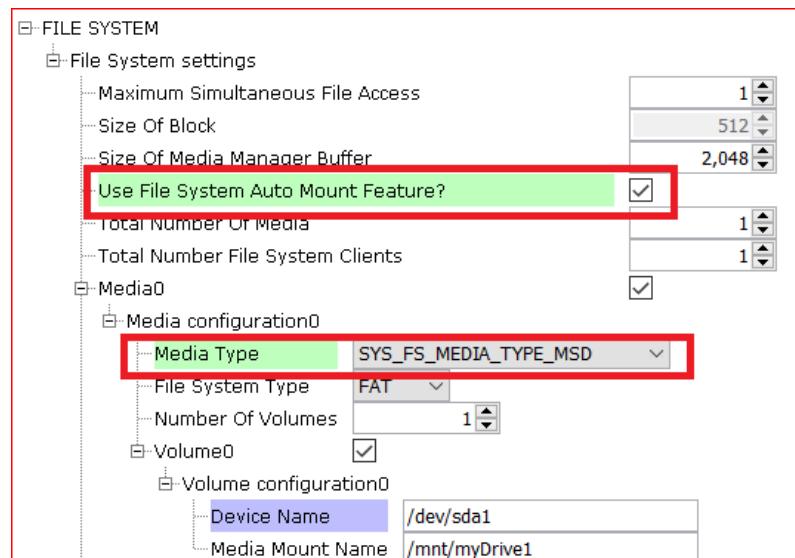
To set the sample rate to a fixed 16KHz, set the PLLA divisor to 2 and the multiplier to 43. Also, set the I2S1 divisor to 63. Please see the two images above.

#### MPLAB Harmony Configurator: WM8904



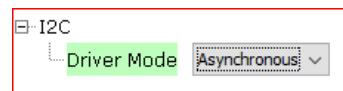
#### MPLAB Harmony Configurator: File System

The Auto Mount feature must be selected in order to expose the media type selection. The media type that is being used in this application is Mass Storage Device. This must be correctly configured, or the storage device will not mount.



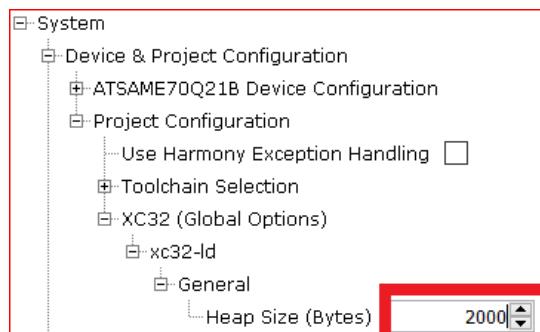
#### MPLAB Harmony Configurator: I2C Driver

If your are using FreeRTOS, set the driver mode back to Asynchronous.



#### MPLAB Harmony Configurator: System

Set the heap size in Harmony if it is not already set for the linker.



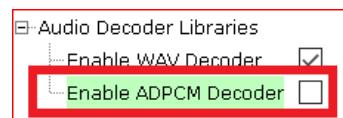
#### MPLAB Harmony Configurator: EFC

Set the memory wait states to 6, if not already set.



#### MPLAB Harmony Configurator: Audio Decoder Libraries

Disable the ADPCM Decoder for this particular app.



Save and generate code for the framework.

## Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

### Description

The parent folder for these files is `audio/apps/audio_enc`. To build this project, you must open the `audio/apps/audio_enc/firmware/* .x` project file in MPLAB X IDE that corresponds to your hardware configuration.

### MPLAB X IDE Project Configurations

The following table lists and describes supported project configurations.

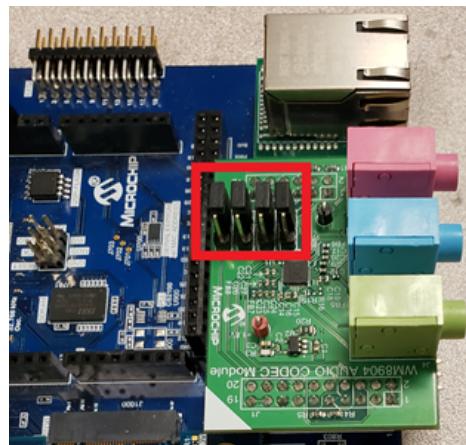
Project Name	BSP Used	Description
<code>audio_enc_sam_e70_xult_wm8904_i2sc</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board with the WM8904 Audio Codec Module attached. The project configuration is for encode/playback of an audio file to/from a USB Mass Storage Device. Data to be tx/rx to/from the Codec via I2S audio protocol using the I2SC PLIB. The WM8904 codec is configured as the slave, and the I2SC peripheral as the master.
<code>audio_enc_sam_e70_xult_wm8904_i2sc_freertos</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board with the WM8904 Audio Codec Module attached. The project configuration is for encode/playback of an audio file to/from a USB Mass Storage Device. Data to be tx/rx to/from the Codec via I2S audio protocol using the I2SC PLIB. The WM8904 codec is configured as the slave, and the I2SC peripheral as the master. This demonstration also uses FreeRTOS.

## Configuring the Hardware

This section describes how to configure the supported hardware.

### Description

This application uses the I2SC PLIB to transfer data to the WM8904 Audio Codec Daughter Board. To connect to the I2SC, the jumpers (J6, J7, J8, and J9) on the WM8904 Codec Daughter Board must be oriented toward the pink, mic in, connector. See the red outlined jumpers in the below image as reference.



 **Note:** The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

## Running the Demonstration

This section demonstrates how to run the demonstration.

### Description

 **Important!** Prior to using this demonstration, it is recommended to review the MPLAB Harmony 3 Release Notes for any known issues.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project based. Refer to Building the Application for details.

1. Connect headphones to the green HP OUT jack of the WM8904 Audio Codec Daughter Board, and a microphone to the pink MIC IN jack.
2. Connect power to the board. The system will be in a wait state for USB to be connected (amber LED1 blinking).
3. Connect a USB mass storage device (thumb drive) to the USB TARGET connector of the SAM E70 Xplained Ultra board. You will probably need a USB-A Female to Micro-B Male adapter cable to do so. The application currently can only record WAVE (.wav) format audio files.

### Control Description

1. Long presses of the push button cause the app to attempt to playback the last encoded file that is saved on the MSD. The two LEDs flash if there is no file that has been encoded.
2. Short presses of the push button cause the app to start or stop encoding.

Button control is shown in the table below.

**Button Operations**

Operation	Function
Long Press (> 1 sec)	Playback last encoded
Short Press (< 1 sec)	Start/Stop Encoding

### Status Indicator Description

1. When the application first starts running, it looks to find an attached storage device. If one is not found, LED1 will toggle on and off about every 100 ms indicating that a storage device is not attached.
2. If/When a storage device is attached, LED1 will turn off.
3. LED2 will turn on when the application is ready to start encoding or playback the last encoded file. If playback is chosen without first creating an encoded file, LED1 and LED2 will toggle briefly then the app will wait for encoding to start.

LED status indication is shown in the table below.

**LED Status**

Operation	LED 1 Status	LED 2 Status
No Storage Device Connected	Toggling	Off
Storage Device Connected	Off	Don't Care
Ready to Encode/Playback	Off	Don't Care
Not Ready to Encode/Playback	Off	Off
Encoding	Off	Toggling
Playback before Encoded File Created	Toggling	Toggling

## audio\_player\_basic

This topic provides instructions and information about the MPLAB Harmony 3 Audio Player Basic demonstration application, which is included in the MPLAB Harmony Library distribution.

### Description

The audio player (audio\_player\_basic) application configures the development board to be in USB Host Mass Storage Device (MSD) mode. The application supports the FAT file system. When a mass storage device is connected to the development board via its Target USB port, the device is mounted, and the application begins to scan for files starting at the root directory. It will search for .wav files up to 10 directory levels deep. A list of files found, and their paths, will be created and stored.

Once the scan is complete, the first track in the list will be opened, validated and played. The application will read the .wav file header to validate. Configuration of the number of channels, sample size, and sample rate stated in the file will be handled by the application for proper playback. If a file that can't be played is found, it will be skipped, and the next sequential file will be tried. If the file can be played, it will then go on and read the .wav file data and write it to the codec for playback.

Command and control of the codec is done through an I2C driver. Data to the codec driver is sent through SSC via I2S Driver and the output will be audible through the headphone output jack of the WM8904 Audio Codec Module connected to the SAM E70 Xplained Ultra board.

Supported audio files are as represented in the table below.

**Supported Format**

Audio Format	Sample Rate (kHz)	Description
PCM	8 to 96	PCM (Pulse Code Modulation) is an uncompressed format. The digital data is a direct representation of the analog audio waveform. The container for the data will be a WAVE file (.wav) format. It is the native file format used by Microsoft Windows for storing digital audio data.

The defines DISK\_MAX\_DIRS and DISK\_MAX\_FILES in the app.h file, determines the maximum number of directories that should be scanned at each level of the directory tree (to prevent stack overflow, the traversing level is limited to 10), and the maximum number of songs in total the demonstration should scan (currently set to 4000 because of memory limitations).

### Architecture

The application runs on the SAM E70 Xplained Ultra Board, which contains a ATSAME70Q21B microcontroller with 2 MB of Flash memory and 384 KB of RAM running at 300 MHz using the following features:

- One push button (SW1)
- Two LEDs (amber LED1 and green LED2)
- WM8904 Codec Daughter Board mounted on a X32 socket

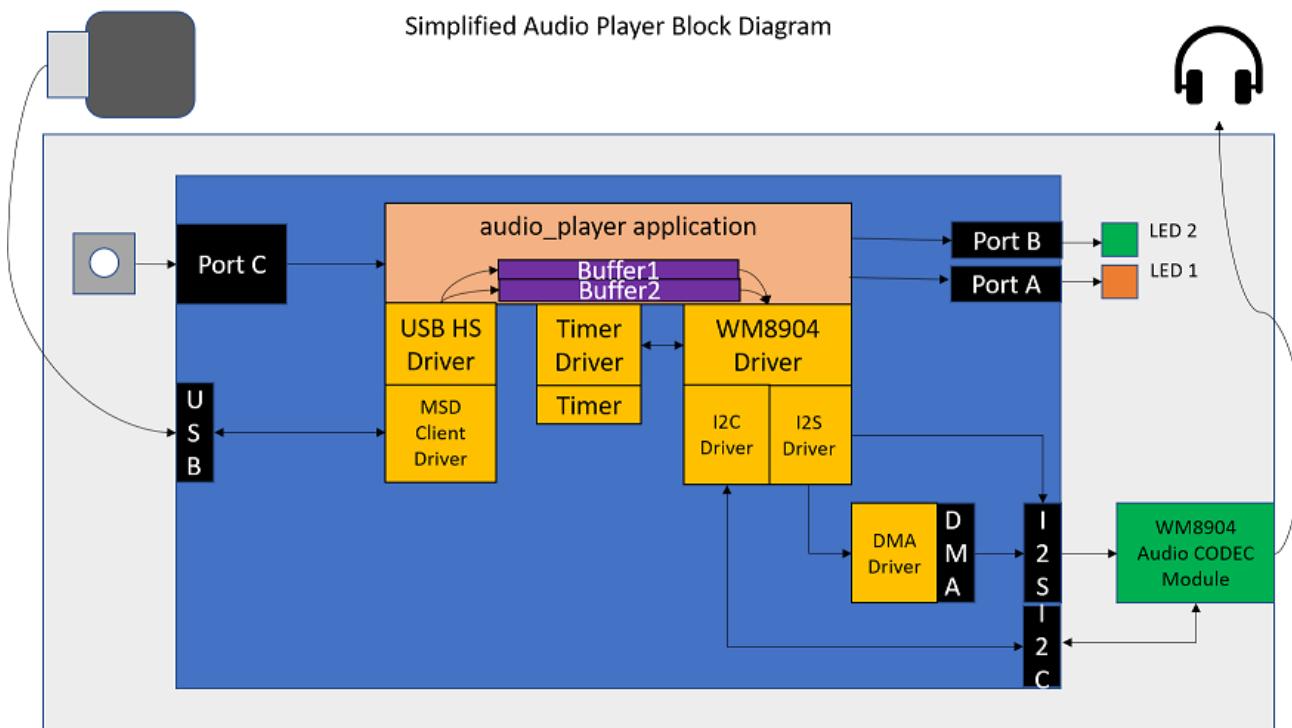
The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

The application currently only supports WAVE (.wav) format files.

The audio\_player\_basic application uses the MPLAB Harmony Configurator to setup the USB MSD Host, file system, codec, and other items in order to read the music files on a USB mass storage device and play it back through the WM8904 Codec Module. It scans WAV (PCM) format files from a mounted FAT USB thumb drive and streams audio through a WM8904 Audio Codec to a pair of headphones. In the application, the number of audio output buffers can always be set to be more than two to enhance the audio quality. The size of input buffer in this application is chosen to be able to handle the data supported.

The following figure shows the architecture for the demonstration.

**Architecture Block Diagram**



## Demonstration Features

- USB MSD Host Client Driver (see USB MSD Host Client Driver Library)
- FAT File System (see File System Service Library)
- Audio real-time buffer handling
- WM8904 Codec Driver (see Audio Codec Driver Libraries)
- I<sup>2</sup>S usage in audio system (see I2S Driver Library)
- DMA (see DMA Peripheral Library)
- Timer (see Timer Peripheral Library)
- GPIO Control (see Port Peripheral Library)

## Harmony Configuration

1. Add BSP->SAM E70 Xplained Ultra BSP
2. If creating Graphics version, add Graphics->Templates->Aria Graphics w/ PDA TM4301B Display
  - a. Yes to all popups.
3. Add Audio->Templates->WM8904 Codec
  - a. Yes to all popups.
4. Add Libraries->USB->Host Stack->MSD Client Driver
  - a. Yes to all popups.
5. Add Harmony->System Services->FILE SYSTEM
6. Remove FreeRTOS if Bare Metal or Graphics versions.
7. Add Harmony->Audio->Decoder->Audio Decoder Libraries
8. Connect MSD Client Driver: DRV\_MEDIA to FILE SYSTEM: DRV\_MEDIA
9. Connect WM8904 Driver:DRV\_I2S to I2S Driver:DRV\_I2S
10. If creating Graphics version, connect MaxTouch Controller:DRV\_I2C to I2C Driver:DRV\_I2C

After reorganization, your graph would look similar to one of the following project graphs. They specify the drivers, services, and libraries being brought into the project to further extend the applications abilities.

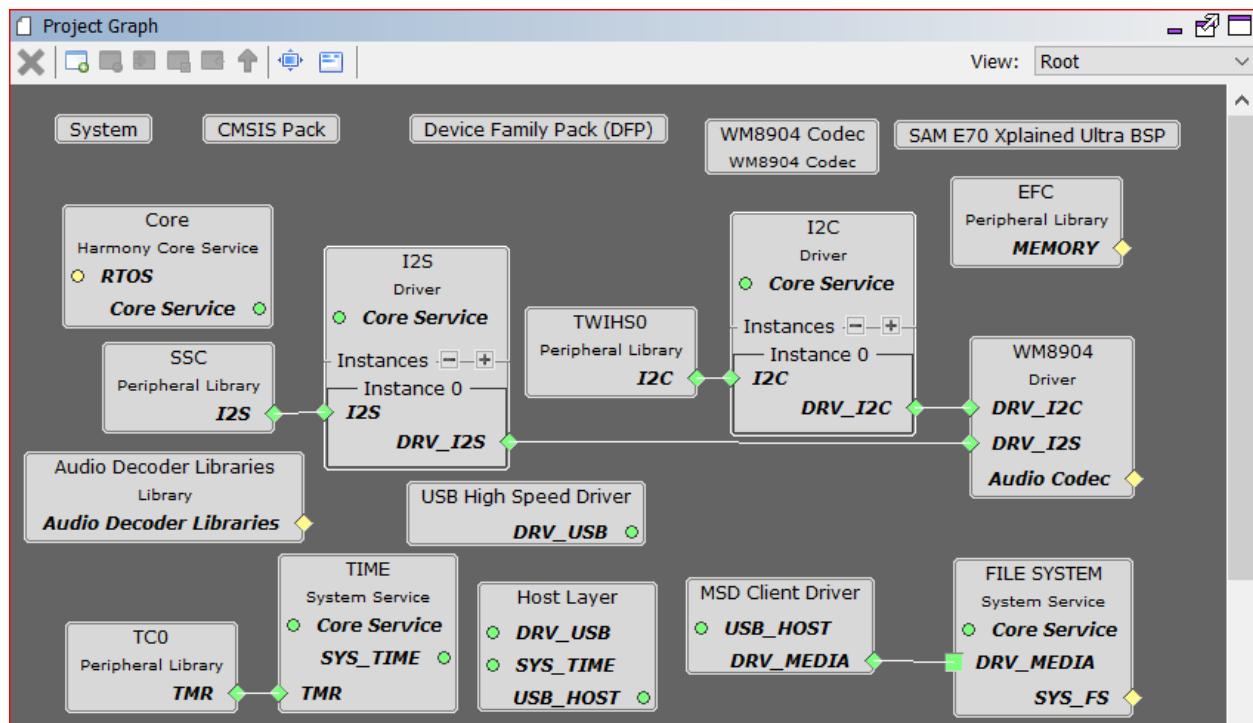


Fig 5 (Project graph of the default E70 bare metal configuration using the SSC)

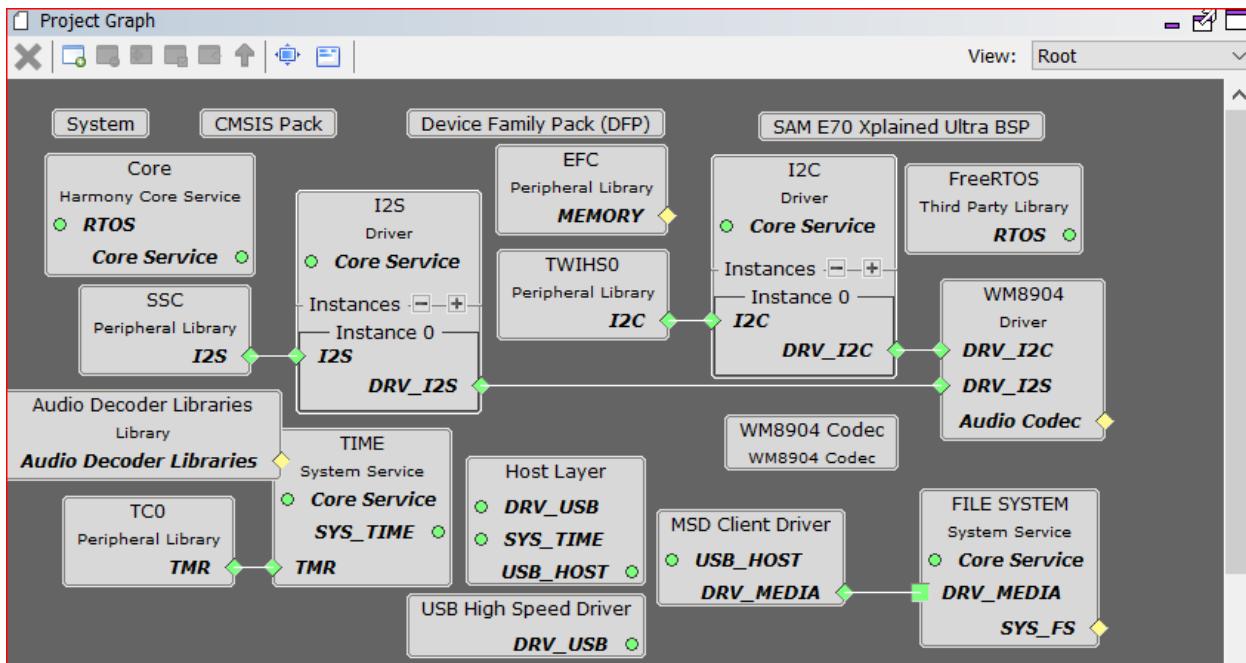


Fig 6 (Project graph of the E70 FreeRTOS configuration using the SSC)

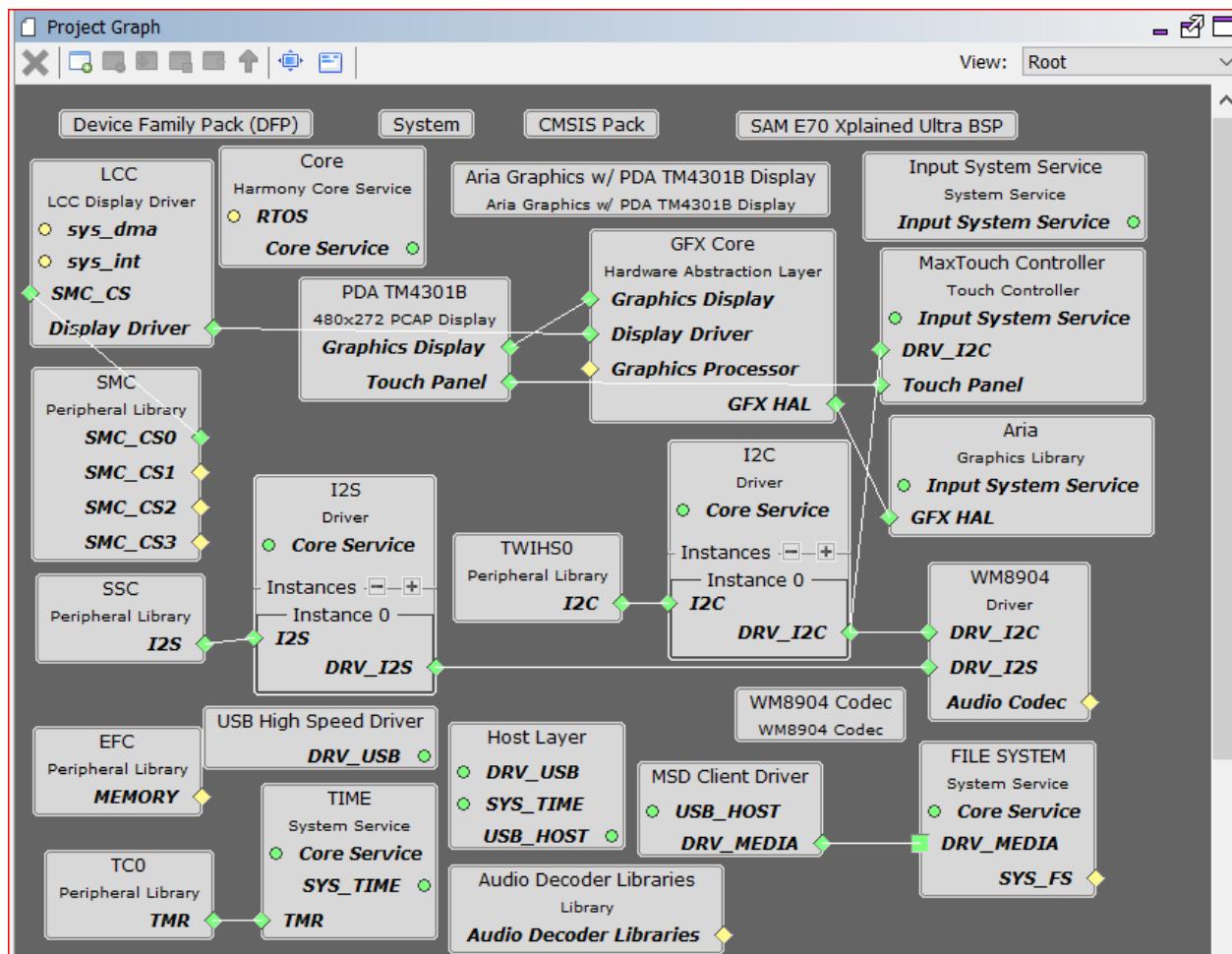


Fig 7 (Project graph of the E70 bare metal configuration using the SSC with the TM4301B graphics display)

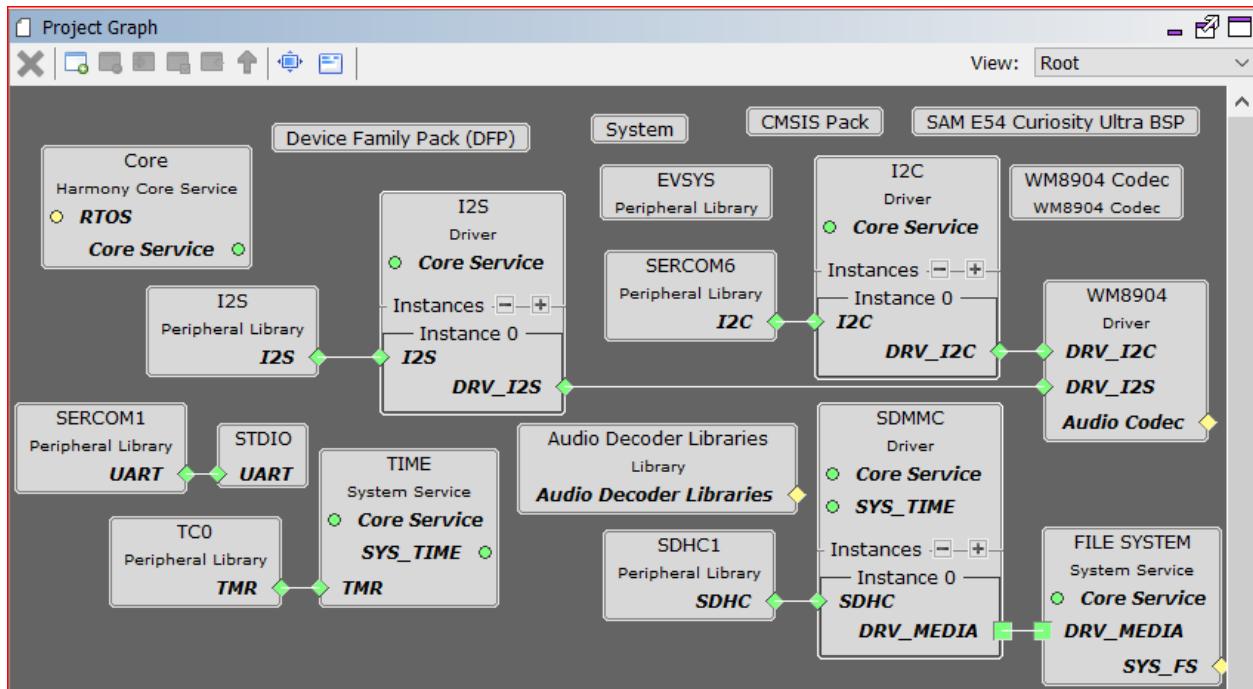


Fig 8 (Project graph of the E54 bare metal configuration using the I2S)

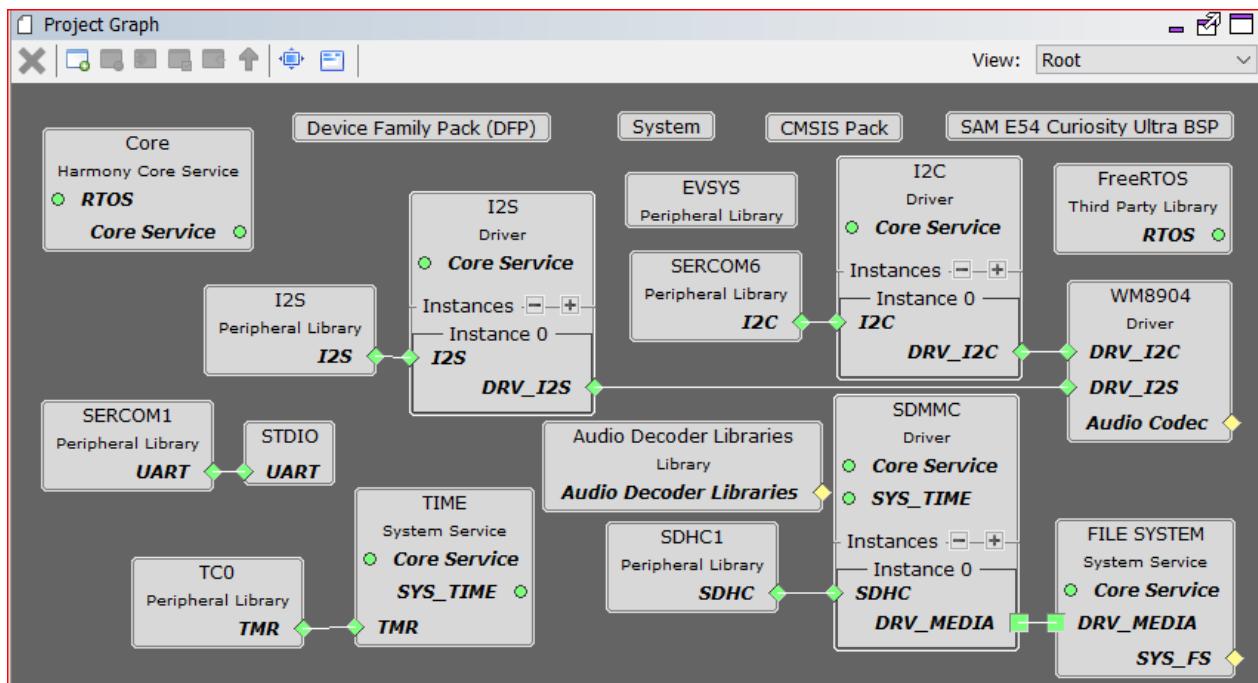


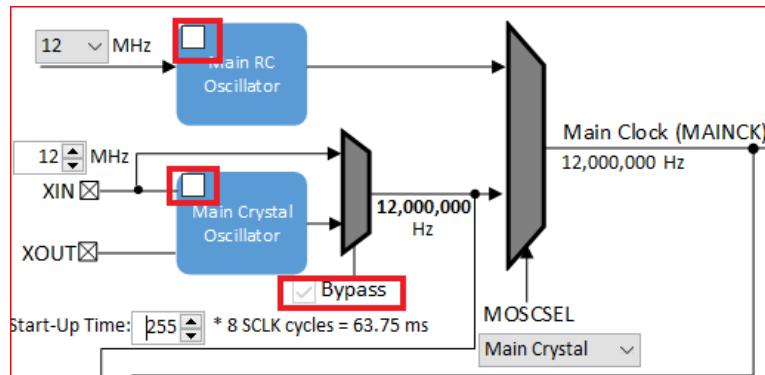
Fig 9 (Project graph of the E54 FreeRTOS configuration using the I2C)

## Tools Setup Differences

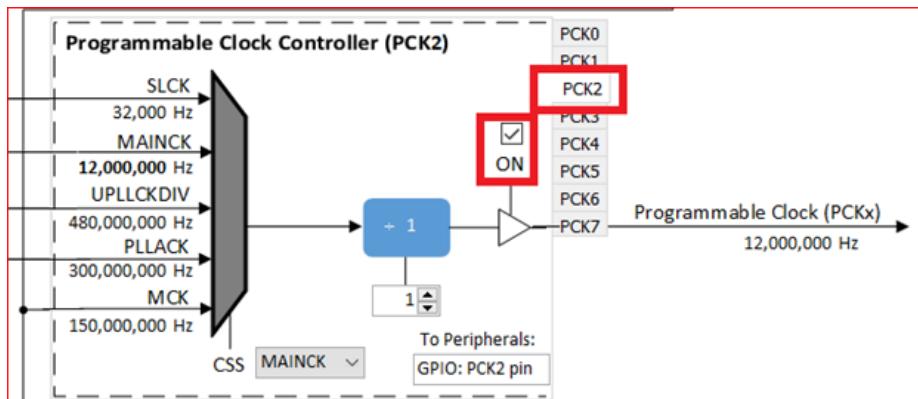
The default configuration should be correct for the majority of the application. The following configurations will need to be changed in order for proper operations.

### MPLAB Harmony Configurator: Tools>Clock Configuration

Uncheck the Main RC Oscillator and check the “Bypass” for the Main Crystal Oscillator. When the Bypass is checked, it will cause the Main Crystal Oscillator to become unchecked.

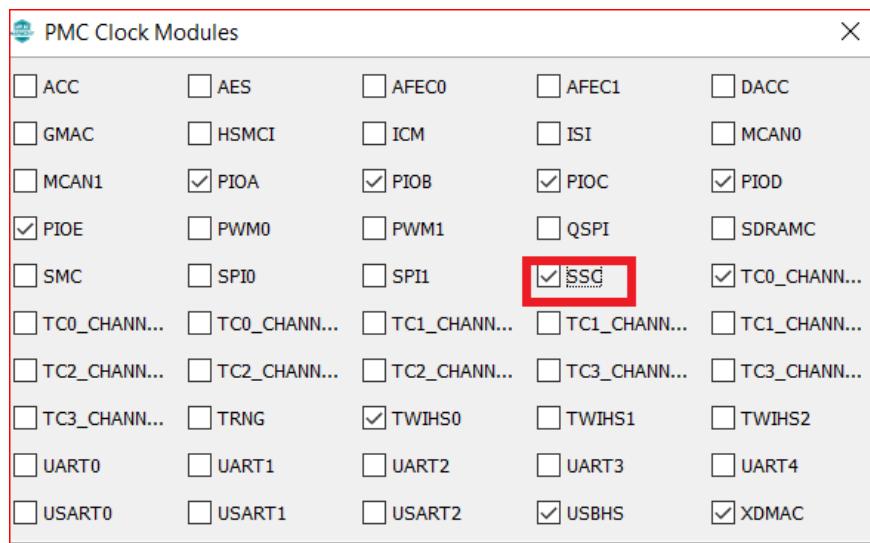


Enable the PCK2 output to enable the WM8904 master clock:

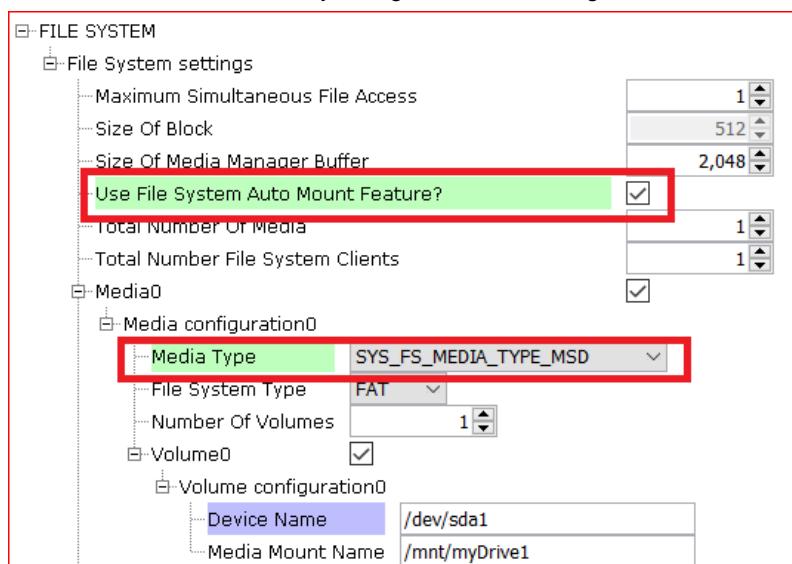


**Clock Diagram>Peripheral Clock Enable**

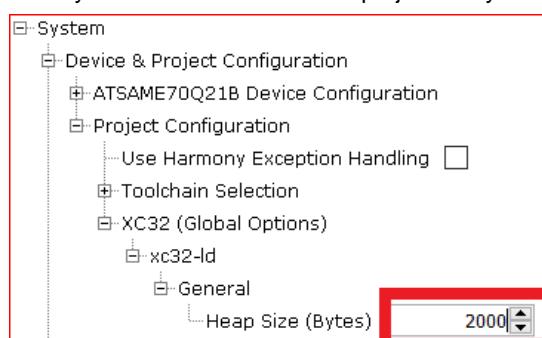
Enable clocking for the SSC.

**MPLAB Harmony Configurator: File System**

The Auto Mount feature must be selected in order to expose the media type selection. The media type that is being used in this application is Mass Storage Device. This must be correctly configured, or the storage device will not mount.

**MPLAB Harmony Configurator: System**

Set the heap size in Harmony if it is not already set for the linker. Certain projects may set the heap to a larger size automatically.

**Building the Application**

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the

demonstration.

## Description

The parent folder for these files is `audio/apps/audio_player_basic`. To build this project, you must open the `audio/apps/audio_player_basic/firmware/*.X` project file in MPLAB X IDE that corresponds to your hardware configuration.

## MPLAB X IDE Project Configurations

The following table lists and describes supported project configurations.

Project Name	BSP Used	Description
<code>apb_sam_e54_ult_wm8904_ssc_sdmmc</code>	<code>sam_e54_cult</code>	This demonstration runs on the ATSAME54P20A processor on the SAM E54 Curiosity Ultra board with the WM8904 Audio Codec Daughter Board. The WM8904 codec is configured as the master, and the I2S peripheral as the slave. The project config is for reading data from a SD card. The data is sent to the headphone output of the codec daughter card via I2S driver.
<code>apb_sam_e54_ult_wm8904_ssc_sdmmc_freertos</code>	<code>sam_e54_cult</code>	This demonstration runs on the ATSAME54P20A processor on the SAM E54 Curiosity Ultra board with the WM8904 Audio Codec Daughter Board. The WM8904 codec is configured as the master, and the I2S peripheral as the slave. The project config is for reading data from a SD card. The data is sent to the headphone output of the codec daughter card via I2S driver. This demonstration uses FreeRTOS to schedule running tasks.
<code>apb_sam_e70_xult_wm8904_ssc</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board with the WM8904 Audio Codec Daughter Board. The WM8904 codec is configured as the master, and the SSC peripheral as the slave. The project configuration is for reading data from a file on a USB Mass Storage Device. The data is sent to the headphone output of the codec daughter card via I2S protocol using the SSC PLib.
<code>apb_sam_e70_xult_wm8904_ssc_freertos</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board with the WM8904 Audio Codec Daughter Board. The WM8904 codec is configured as the master, and the SSC peripheral as the slave. The project configuration is for reading data from a file on a USB Mass Storage Device. The data is sent to the headphone output of the codec daughter card via I2S protocol using the SSC PLib. This demonstration uses FreeRTOS to schedule tasks to run.
<code>apb_sam_e70_xult_wm8904_ssc_tm4301b</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board with the WM8904 Audio Codec Daughter Board. The WM8904 codec is configured as the master, and the SSC peripheral as the slave. The project configuration is for reading data from a file on a USB Mass Storage Device. The data is sent to the headphone output of the codec daughter card via I2S protocol using the SSC PLib. This demonstration also uses graphics to display status and controls for the board.

## Configuring the Hardware

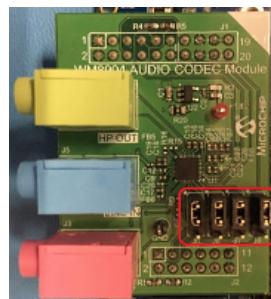
This section describes how to configure the supported hardware.

## Description

Using the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, using the SSC PLIB:

Jumper J204, which is next to the SAM E70 Xplained Ultra logo, should be jumpered for LED2.

To connect to the SSC, the jumpers (J6, J7, J8, and J9) on the WM8904 Codec Daughterboard must be oriented away from the pink, mic in, connector. See the red outlined jumpers in the below image as reference.



**Note:** The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

## Running the Demonstration

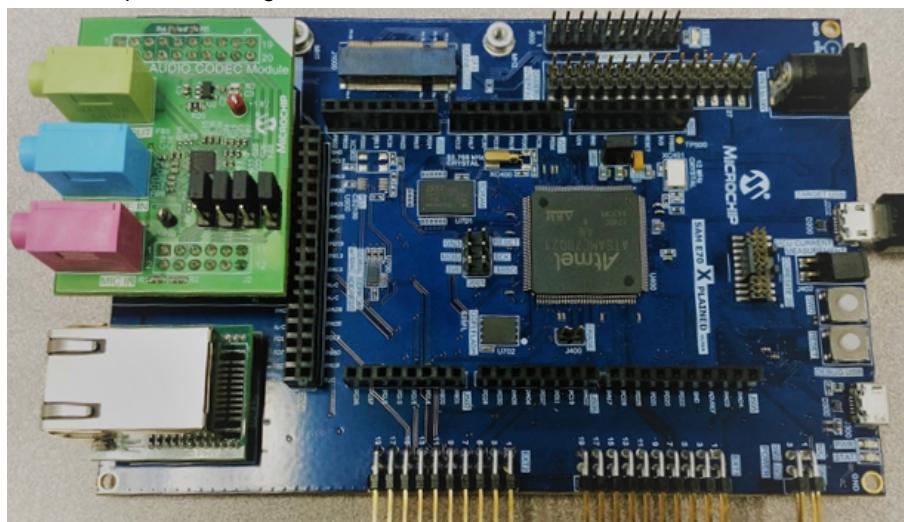
This section demonstrates how to run the demonstration.

## Description

**Important!** Prior to using this demonstration, it is recommended to review the MPLAB Harmony 3 Release Notes for any known issues.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project based. Refer to Building the Application for details.

1. Connect headphones to the HP OUT jack of the WM8904 Audio Codec Daughter Board (see **Figure 1**).
2. Connect power to the board. The system will be in a wait state for USB to be connected (amber LED1 blinking).
3. Connect a USB mass storage device (thumb drive) that contains songs of supported audio format to the USB TARGET connector of the SAM E70 Xplained Ultra board. You will probably need a USB-A Female to Micro-B Male adapter cable to do so. The application currently can only stream WAVE (.wav) format audio files.
4. When the USB device is connected the system will scan for audio files. Once the scanning is complete and at least one file is found (green LED2 on steady), listen to the audio output on headphones connected to the board. Use Switch SW1 as described under Control Description to change the volume or advance to the next track.



**Figure 1: WM8904 Audio Codec Daughter Board on SAM E70 Xplained Ultra board**

## Control Description

Long presses of the push button cycle between volume control and the linear track change mode.

When in volume control mode, short presses of the push button cycle between Low, Medium, High, and Mute volume outputs.

While in the Mute mode, a pause of the playback will also take place.

When in the linear track change mode, short presses of the push button will seek to the end of the currently playing track and start the next track that was found in sequence. After all tracks have been played, the first track will start again in the same sequential order.

Button control is shown in the table below.

#### Button Operations

Long Press (> 1 sec)	Short Press (< 1 sec)
Volume Control	Low (-66 dB)
	Medium (-48 dB)
	High (0 dB)
	Mute/Pause
Linear Track Change	Next sequential track

#### Status Indicator Description

When the application first starts running, it looks to find an attached storage device. If one is not found, LED1 will toggle on and off about every 100ms indicating that a storage device is not attached.

When a storage device is attached, LED1 will turn off. At this time, the file system will be scanned for WAVE files with a .wav extension.

If no WAVE files are found on the storage device, LED2 will remain off and scanning of the device will continue.

If any WAVE files are found, LED2 will turn on and playback of the first file found in sequence will start.

LED status indication is shown in the table below.

#### LED Status

Operation	LED1 Status (Red)	LED2 Status (Green)
No Storage Device Connected	Toggle 100ms	Off
Storage Device Connected	Off	See Files Found Operation
Playback: Volume Control	Off	See Files Found Operation
Playback: Volume Mute	Toggle 500ms	See Files Found Operation
Playback: Linear Track Change	On	See Files Found Operation
Files Found (Yes/No)	See above operations	On/Off

## audio\_signal\_generator

This topic provides instructions and information about the MPLAB Harmony 3 Audio Signal Generator demonstration application, which is included in the MPLAB Harmony Library distribution.

### Description

In this demonstration application the Codec Driver sets up the WM8904 Codec. The demonstration sends out generated audio waveforms (sine wave, square wave, sawtooth wave, and triangle wave) with volume, duration and frequency modifiable through buttons on a touch screen. Success is indicated by an audible output corresponding to displayed parameters.

The tones can be varied from 50 Hz to 6000 Hz, sent by default at 48,000 samples/second, which is modifiable in the MHC as described below.

To know more about the MPLAB Harmony Codec Drivers, configuring the Codec Drivers, and the APIs provided by the Codec Drivers, refer to Codec Driver Libraries.

### Architecture

[SAM E70 Xplained Ultra Projects:](#)

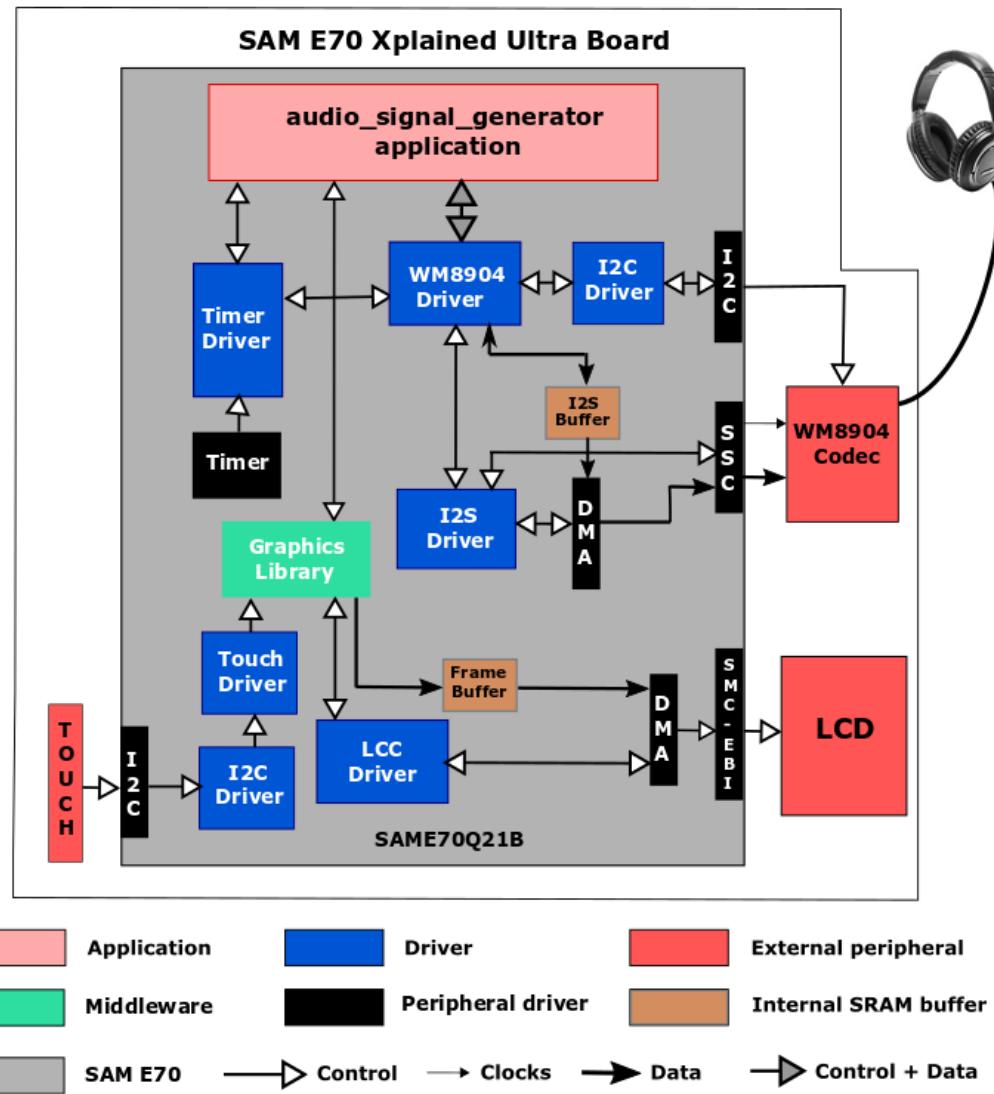
There is one project which runs on the SAM E70 Xplained Ultra Board, which contains a ATSAME70Q21B microcontroller with 2 MB of Flash memory and 384 KB of RAM running at 300 MHz using the following features:

- WM8904 Codec Daughter Board mounted on a X32 socket
- PDA TM4301B 480x272 (WQVGA) Display

The SAM E70 Xplained Ultra board does not include either the WM8904 Audio Codec daughterboard or the TM4301B graphics card, which are sold separately on microchipDIRECT as part numbers AC328904 and AC320005-4, respectively.

The program takes up to approximately 18% (350 KB) of the ATSAME70Q21B microcontroller's program space. The 16-bit configuration uses 87% (332 KB) of the RAM. A 32 KB heap is used.

The following figure illustrates the application architecture for the SAM E70 Xplained Ultra configuration:



The WM8904 codec is configured in master mode, meaning it generates the  $I^2S$  clocks (LRCLK and BCLK), and the SSC peripheral is configured as a slave. The I<sup>2</sup>SC peripheral cannot be used with this project as its interface conflicts with the graphics interface.

The SAM E70 microcontroller (MCU) runs the application code, and communicates with the WM8904 codec via an  $I^2C$  interface. The audio interface between the SAM E70 and the WM8904 codec use the  $I^2S$  interface. Audio is configured as 16-bit, 48,000 samples/second,  $I^2S$  format. (16-bit, 48 kHz is the standard rate used for DVD audio. An alternate that could be used is 44,100 samples/second. This is the same sample rate used for CD's. The sample rate is configurable in the MHC).

The Master Clock (MCLK) signal used by the codec is generated by the Peripheral Clock section of the SAM E70, and is fixed at 12 MHz.

As with any MPLAB Harmony application, the SYS\_Initialize function, which is located in the initialization.c source file, makes calls to initialize various subsystems as needed, such as the clock, ports, board support package (BSP), display, WM8904

codec, I2S, I2C, DMA, timers, and interrupts.

The codec driver and the application state machines are all updated through calls located in the SYS\_Tasks function in the tasks.c file.

The application code is contained in the several source files. The application's state machine (APP\_Tasks) is contained in app.c. It first gets a handle to a timer driver instance and sets up a periodic (alarm) callback. In the next state it gets a handle to the codec driver by calling the DRV\_CODEC\_Open function with a mode of DRV\_IO\_INTENT\_WRITE and sets up the volume.

The application state machine then registers an event handler APP\_CODEC\_BufferEventHandler as a callback with the codec driver (which in turn is called by the DMA driver).

Two buffers are used for generating the various waveformse in a ping-pong fashion. Initially values for the first buffer are calculated, and then the buffer is handed off to the DMA using a DRV\_CODEC\_BufferAddWrite. While the DMA is transferring data to the SSC peripheral, causing audio to be sent to the codec over I<sup>2</sup>S, the program calculates the values for the next cycle. (In the current version of the program, this is always the same unless the frequency is changed manually.) Then when the DMA callback Audio\_Codec\_BufferEventHandler is called, the second buffer is handed off and the first buffer re-initialized, back and forth.

A local routine called initSweep calculates the total number of cycles that are to be generated, based on the starting frequency, ending frequency and sample rate. This results in an average period, which is divided into the duration to yield the the total number of cycles. The cycles for each frequency step is then calculated, and based on this, the number of cycles per buffer is calculated based on the size of the buffer.

A second local routine fillInNumSamplesTable is then called to fill in the current buffer based on the calculated parameters. A table (appData.numSamples1 or 2) is filled in with the number of samples for each cycle to be generated. This table with the number of samples per cycle to be generated is then passed to the function APP\_TONE\_LOOKUP\_TABLE\_Initialize along with which buffer to work with (1 or 2) and the sample rate.

For sine waves, the 16-bit value for each sample is calculated based on the relative distance (angle) from 0, based in turn on the current sample number and total number of samples for one cycle. First the angle is calculated in radians:

```
double radians = (M_PI*(double)(360.0/(double)currNumSamples)*(double)i)/180.0;
```

Then the sample value is calculated using the sine function:

```
lookupTable[i].leftData = (int16_t)(0x7FFF*sin(radians));
```

If the number of samples divides into the sample rate evenly, then only 1/4 (90°) of the samples are calculated, and the remainder is filled in by reflection. Otherwise each sample is calculated individually. Before returning, the size of the buffer is calculated based on the number of samples filled in.

For the other waveforms, the 16-bit value of each sample is computed algorithmically based on the shape of the waveform and the position of the sample within the cycle -- square waves, half positive and half negative; sawtooth a steady ramp, and triangle waves, a ramp up followed by a ramp down.

## Demonstration Features

- Calculation of a sine wave based on the number of samples and sample rate using the sin function, with reflection if possible
- Calculation of other waveforms based on the number of samples and sample rate and shape of the waveform.
- Uses the Codec Driver Library to write audio samples to the WM8904
- At a lower level, uses the I2S Driver Library between the codec library and the chosen peripheral (SSC or I2SC) to send the audio to the codec
- Use of ping-pong buffers and DMA
- Use of two timers: one as a periodic 1 ms timer for the application for button debouncing, and a second used by the Codec Driver (see Timer Driver Library)

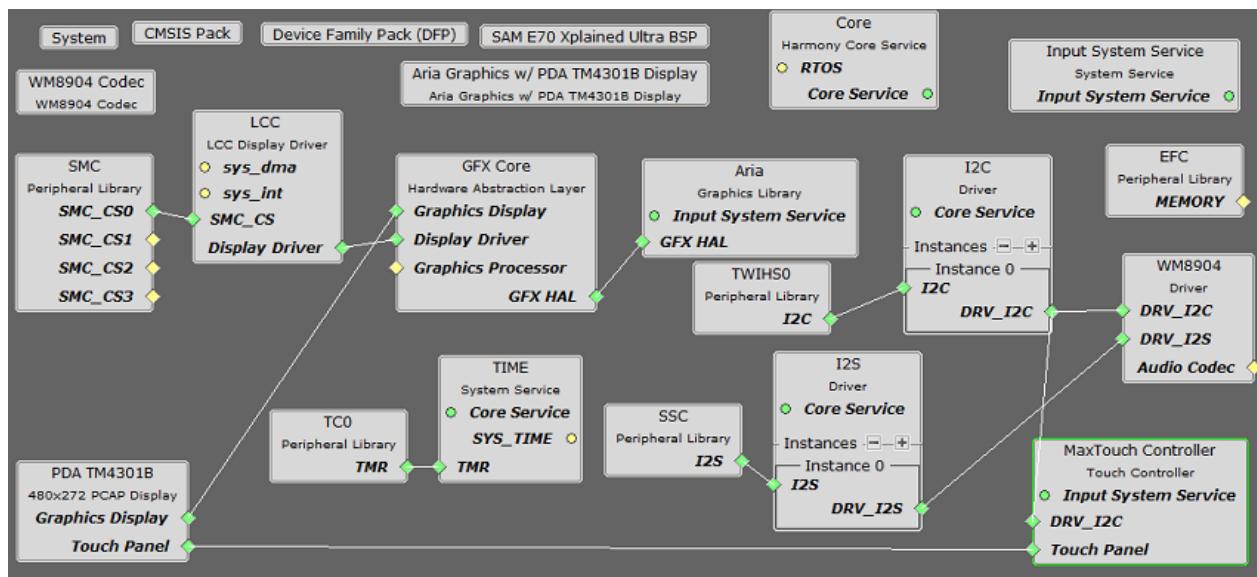
## Tools Setup Differences

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Chose the Configuration name the same based on the BSP used (SAM E70 Xplained Ultra). Select the appropriate processor (ATSAME70Q21B). Click Finish.

In the MHC, under Available Components select the BSP (SAM E70 Xplained Ultra). Under *Graphics>Templates*, double-click on Aria Graphics w/ PDA TM4301B Display. Answer Yes to all questions except for the one regarding FreeRTOS; answer No to that one.

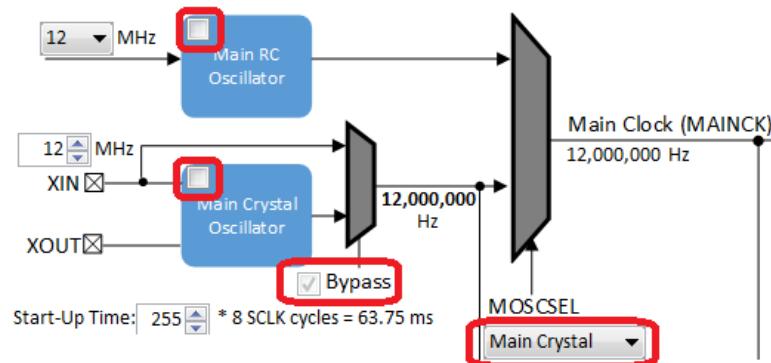
Then under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions.

You should end up with a project graph that looks like this, after rearranging the boxes:



Click on the WM8904 Driver. In the Configurations Options, set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

If using the SAM E70 Xplained Ultra board, in the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



Also in the Clock Diagram, in the PCK2 tab of the **Programmable Clock Controller** section, check the On checkbox, and set CSS to MAINCLK (12 MHz). Then check the SSC checkbox in the **Peripheral Clock Controller** section.

It is also possible to change the audio format from 16 to 32-bits, and from I2S to Left Justified (SSC only). These changes need to be done in the MHC in both the WM8904, and SSC/I2SC Peripherals. In the current application code (app.h), a #define is also set to the current width.

## Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

## Description

The parent folder for these files is `audio/apps/audio_signal_generator`. To build this project, you must open the `audio/apps/audio_signal_generator/firmware/*.X` project file in MPLAB X IDE that corresponds to your hardware configuration.

### MPLAB X IDE Project Configurations

The following table lists and describes supported project configurations.

Project Name	BSP Used	Description
audio_sig_gen_sam_e70_xult_wm8904_ssc_wqvg	sam_e70_xult	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave.

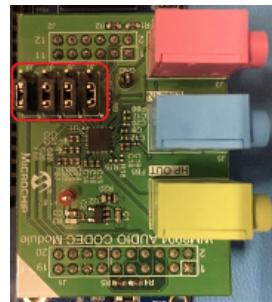
## Configuring the Hardware

This section describes how to configure the supported hardware.

### Description

Attach the flat cable of the PDA TM4301B 480x272 (WQVGA) display to the 565 daughterboard connected to the SAM E70 Xplained Ultra board GFX CONNECTOR.

The WM8904 Audio Codec Daughter Board will be using the SSC PLIB; all jumpers on the WM8904 should be toward the **front**:



→ **Note:** The SAM E70 Xplained Ultra board does not include either the WM8904 Audio Codec daughterboard or the PDA TM4301B 480x272 (WQVGA) display. They are sold separately on microchipDIRECT as part numbers AC328904 and AC320005-4 respectively.

## Running the Demonstration

This section demonstrates how to run the demonstration.

### Description

! **Important!** Prior to using this demonstration, it is recommended to review the MPLAB Harmony 3 Release Notes for any known issues.

Continuous sine tones of four frequencies can be generated. **Table 1** provides a summary of the button actions that can be used to control the volume and frequency.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project based. Refer to [Building the Application](#) for details.

1. Connect headphones to the HP OUT jack of the WM8904 Audio Codec Daughter Board (see [Figure 1](#)).

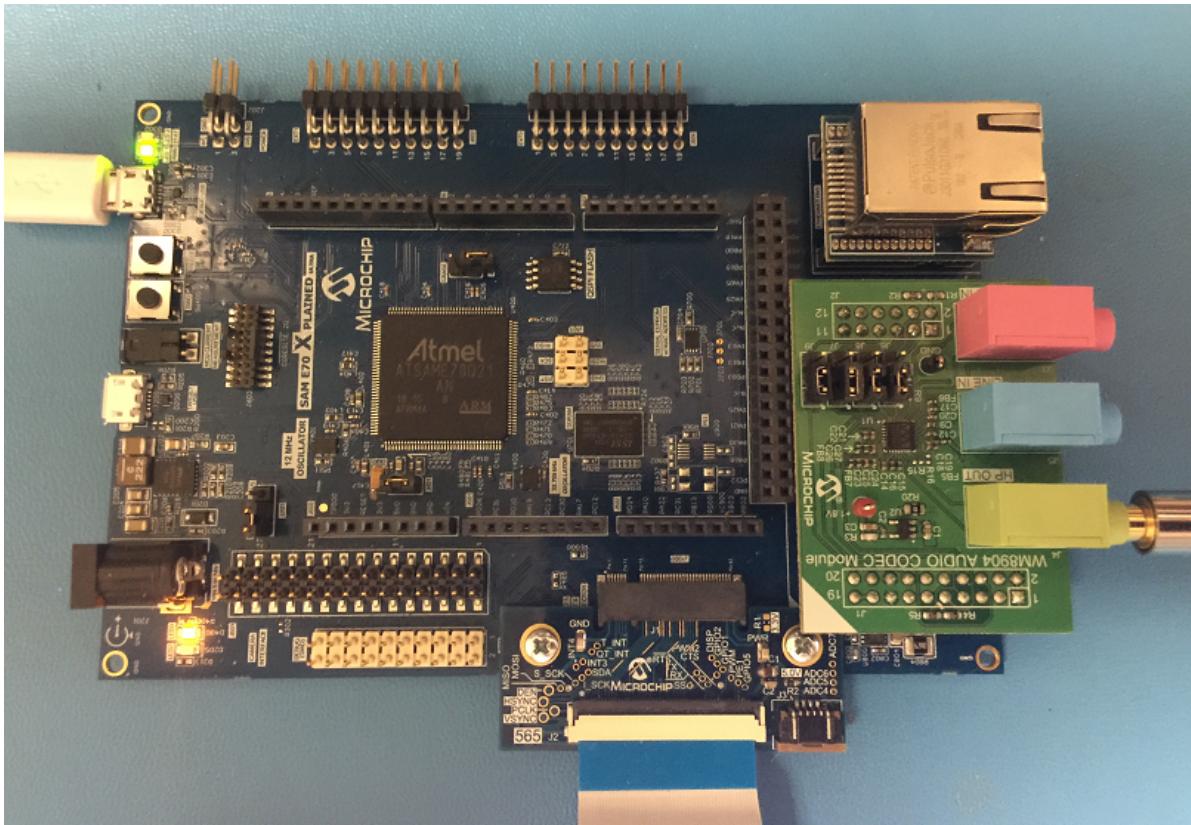
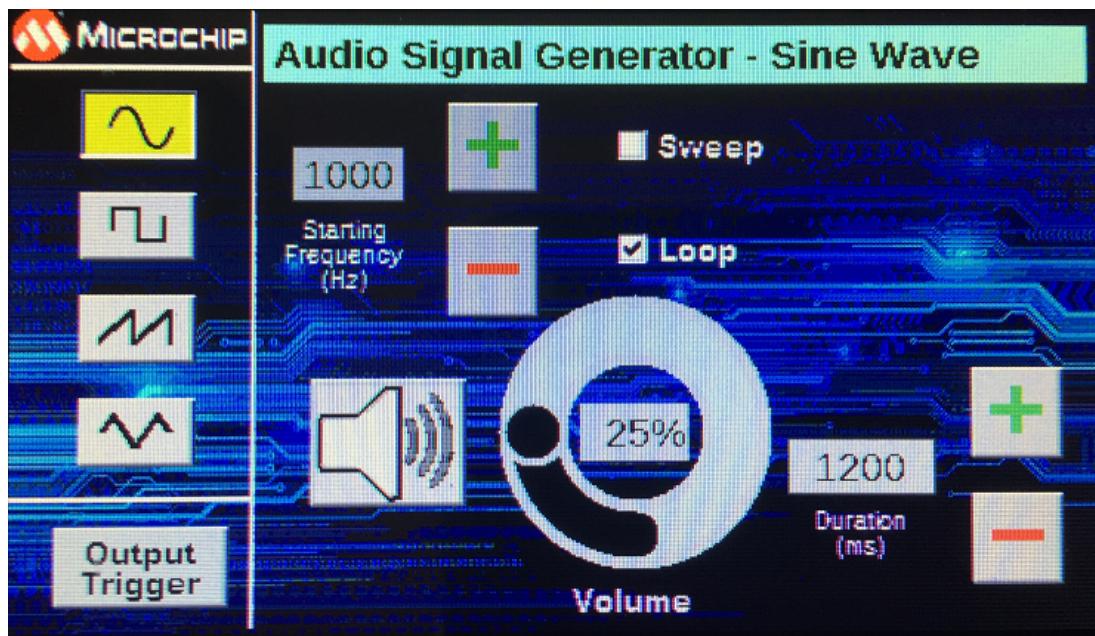
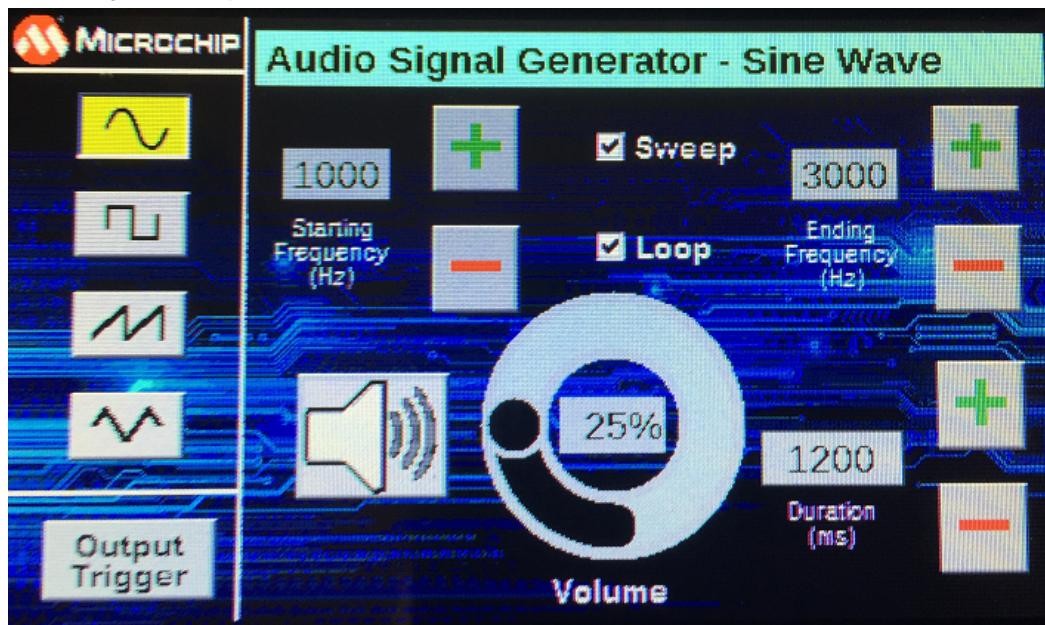


Fig 1. SAM E70 Xplained Ultra Board with WM8904 Codec Daughterboard

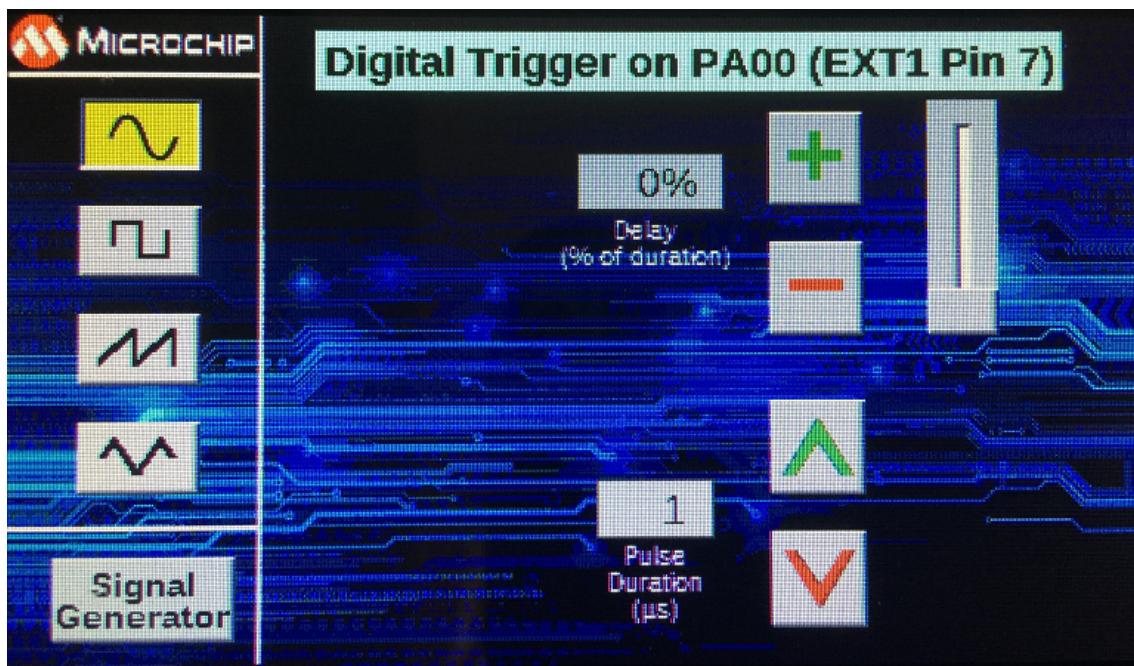
2. Initially the program will be a single-tone continuous sine wave mode, frequency set at 1000 Hz, and a 25% volume level.
3. Turn the tone on and off by tapping on the speaker icon in the center of the screen, to the left of the Volume control. The sound waves will change to a red X when enabled.
4. Change the waveform type by pressing one of the four buttons on the left of the screen: sine, square, sawtooth, and triangle wave.
5. Change the volume by rotating the circular control in the middle of the screen.
6. To switch from a continuous tone to a timed one, tap the Loop checkbox. When unchecked, the tone duration will be determined by the Duration setting in the lower right of the screen. Durations can range from 10 ms to 20000 ms (20 seconds). Pressing the + button will increase the duration by 10 ms; pressing the - button will decrease by 10 ms. Holding either button down over one second will change it at a faster rate.
7. The frequency can be adjusted using the Starting Frequency control. Pressing the + button will increase the frequency by 10 Hz; pressing the - button will decrease by 10 Hz. Holding either button down over one second will change it at a faster rate. Some frequencies can not be output exactly.



8. If the Sweep checkbox is tapped so it becomes checked, an Ending Frequency control becomes visible. This used to sweep the frequency from a Starting Frequency to an Ending Frequency over a specified Duration. The frequency can be adjusted the same as for the Starting Frequency control.



9. Pressing the Output Trigger button on the lower left corner of the display switches to a second screen, which is used to control a digital trigger that is output on pin PA00 (pin 7 of the EXT1 connector on the SAM E70 Xplained Ultra board), which by default is 1  $\mu$ s long. The Pulse Duration control can change the pulse width to either 1, 5, or 10  $\mu$ s using up and down arrow buttons.  
 10. By default, the pulse is output at the beginning of a sweep cycle. But this can be delayed using the Delay control, as a per cent of the Duration. Either + / - buttons of the slider can be used to change the Delay.



11. Pressing the Signal Generator button on the lower left corner of the display switches back to the first screen.

## audio\_tone

This topic provides instructions and information about the MPLAB Harmony 3 Audio Tone demonstration application, which is included in the MPLAB Harmony Library distribution.

### Description

In this demonstration application the Codec Driver sets up the WM8904 Codec. The demonstration sends out generated audio waveforms (sine tone) with volume and frequency modifiable through the on-board push button. Success is indicated by an audible output corresponding to displayed parameters.

The sine tone is one of four frequencies: 250 Hz, 500 Hz, 1 kHz, and 2 kHz, sent by default at 48,000 samples/second, which is modifiable in the MHC as described below.

To know more about the MPLAB Harmony Codec Drivers, configuring the Codec Drivers, and the APIs provided by the Codec Drivers, refer to Codec Driver Libraries.

### Architecture

There are seven different projects packaged in this application.

#### SAM E54 Curiosity Ultra Projects:

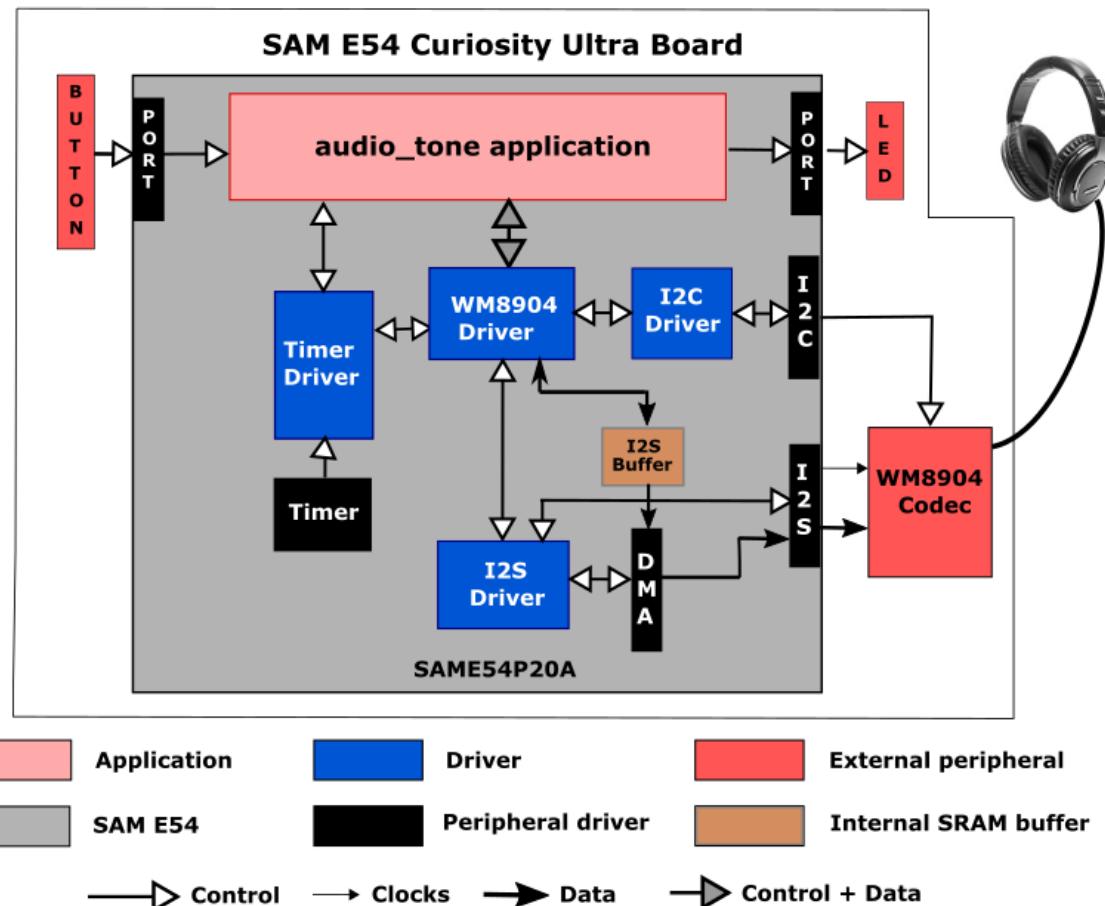
Two projects run on the SAM E54 Curiosity Ultra Board, which contains a ATSAME54P20A microcontroller with 1 MB of Flash memory and 256 KB of RAM running at 48 MHz using the following features:

- Two push buttons (SW1 and SW2)
- Two LEDs (LED1 and 2)
- WM8904 Codec Daughter Board mounted on a X32 socket

The SAM E54 Curiosity Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

The non-RTOS version of the program takes up to approximately 3% (28 KB) of the ATSAME54P20A microcontroller's program space. The 16-bit configuration uses 45% (115 KB) of the RAM. No heap is used. For the FreeRTOS project, the program takes up to approximately 1% (22 KB) of the ATSAME54P20A microcontroller's program space, and the 16-bit configuration uses 60% (155 KB) of the RAM. No heap is used.

The following figure illustrates the application architecture for the two SAM E54 Xplained Ultra configurations (RTOS not shown):



The I<sup>2</sup>S (Inter-IC Sound Controller) is used with the WM8904 codec. The WM8904 is configured in master mode, meaning it generates the I<sup>2</sup>S clocks (LRCLK and BCLK), and the I<sup>2</sup>S peripheral is configured as a slave.

#### SAM E70 Xplained Ultra Projects:

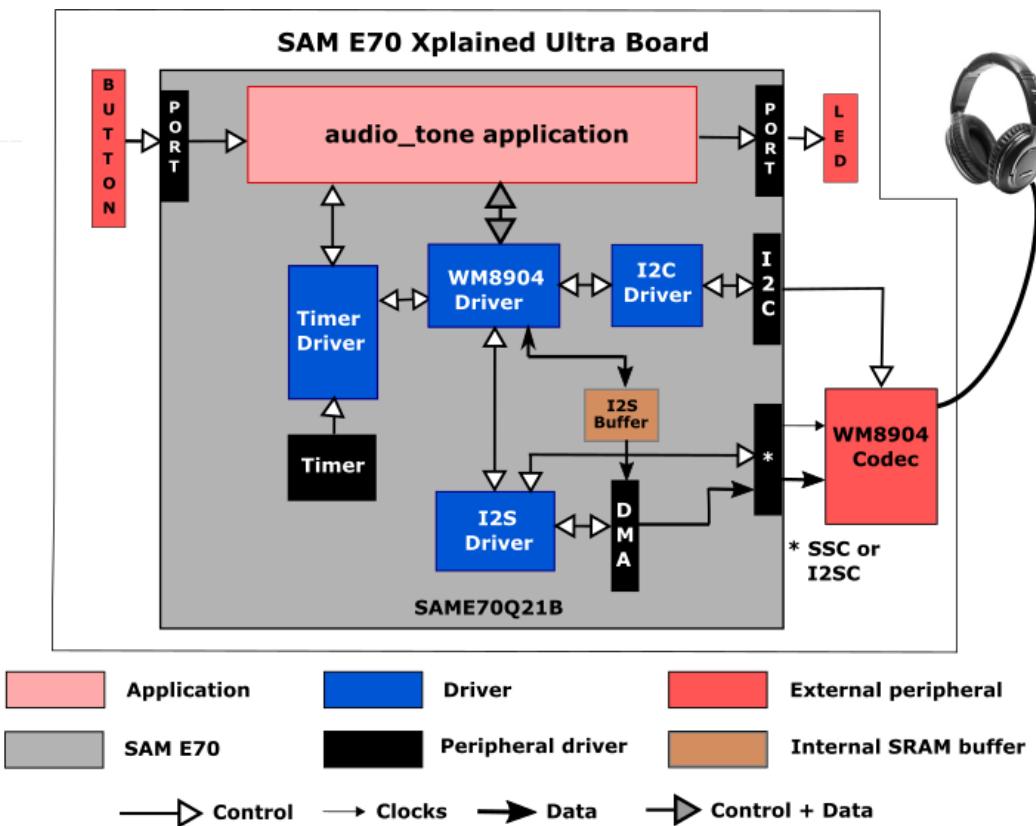
Four projects run on the SAM E70 Xplained Ultra Board, which contains a ATSAME70Q21B microcontroller with 2 MB of Flash memory and 384 KB of RAM running at 300 MHz using the following features:

- One push button (SW1, may be labeled as SW0 on some boards)
- Two LEDs (LED1 and 2)
- AK4954 or WM8904 Codec Daughter Board mounted on a X32 socket

The SAM E70 Xplained Ultra board does not include the AK4954 or WM8904 Audio Codec daughterboards, which are sold separately on microchipDIRECT as part numbers AC324954 and AC328904, respectively.

The two non-RTOS versions of the program take up to approximately 1% (18 KB) of the ATSAME70Q21B microcontroller's program space. The 16-bit configuration uses 30% (115 KB) of the RAM. No heap is used. For the FreeRTOS project, the program takes up to approximately 1% (22 KB) of the ATSAME70Q21B microcontroller's program space, and the 16-bit configuration uses 41% (155 KB) of the RAM. No heap is used.

The following figure illustrates the application architecture for the three SAM E70 Xplained Ultra configurations using the WM8904 (RTOS not shown). The AK4954 version is the same with the substitution of the AK4954 Driver and Codec blocks.



The AK4954 codec is only used with the SSC (Synchronous Serial Controller). The WM8904 is configured in slave mode and the SSC peripheral is a master and generates the I<sup>2</sup>SC clocks.

Depending on the project, either the SSC (Synchronous Serial Controller) or I<sup>2</sup>SC (Inter-IC Sound Controller) is used with the WM8904 codec, selected by a strapping option on the WM8904 daughterboard. When using the SSC interface, the WM8904 is configured in master mode, meaning it generates the I<sup>2</sup>S clocks (LRCLK and BCLK), and the SSC peripheral is configured as a slave. When using the I<sup>2</sup>SC interface, the WM8904 is configured in slave mode and the SSC peripheral is a master and generates the I<sup>2</sup>SC clocks. The other two possibilities (SSC as master and WM8904 as slave, or I<sup>2</sup>SC as slave and WM8904 as master) are possible, but not discussed.

#### SAMV71 Xplained Ultra Project:

One project runs on the SAMV71 Xplained Ultra Board, which contains a ATSAMV71Q21B microcontroller with 2 MB of Flash memory and 384 KB of RAM running at 300 MHz using the following features:

- One push button (SW1)
- Two LEDs (LED0 and 1)
- WM8904 codec (on board)

The program takes up to approximately 1% (18 KB) of the ATSAME70Q21B microcontroller's program space. The 16-bit configuration uses 30% (115 KB) of the RAM (with 15K of that used by the three audio buffers). No heap is used.

The architecture is the same as for the SAM E70 Ultra board configurations; however only the SSC is available.

The same application code is used without change between the seven projects.

The SAM E54/SAM E70/SAM V71 microcontroller (MCU) runs the application code, and communicates with the AK4954 or WM8904 codec via an I<sup>2</sup>C interface. The audio interface between the microcontroller and the codec use the I<sup>2</sup>S interface. Audio is configured as 16-bit, 48,000 samples/second, I<sup>2</sup>S format. (16-bit, 48 kHz is the standard rate used for DVD audio. An alternate that could be used is 44,100 samples/second. This is the same sample rate used for CD's. The sample rate is configurable in the MHC.)

The Master Clock (MCLK) signal used by the codec is generated by the Peripheral Clock section of the microcontroller, and is fixed at 12 MHz.

The button and LEDs are interfaced using GPIO pins. There is no screen.

As with any MPLAB Harmony application, the SYS\_Initialize function, which is located in the initialization.c source file, makes calls to initialize various subsystems as needed, such as the clock, ports, board support package (BSP), codec, I<sup>2</sup>S, I<sup>2</sup>C,

DMA, timers, and interrupts.

The codec driver and the application state machines are all updated through calls located in the SYS\_Tasks function in the tasks.c file.

The application code is contained in the several source files. The application's state machine (APP\_Tasks) is contained in app.c. It first initializes the application, which includes APP\_Tasks then periodically calls APP\_Button\_Tasks to process any pending button presses.

Then the application state machine inside APP\_Tasks is given control, which first gets a handle to a timer driver instance and sets up a periodic (alarm) callback. In the next state it gets a handle to the codec driver by calling the DRV\_CODEC\_Open function with a mode of DRV\_IO\_INTENT\_WRITE and sets up the volume.

The application state machine then registers an event handler APP\_CODEC\_BufferEventHandler as a callback with the codec driver (which in turn is called by the DMA driver).

Two buffers are used for generating a sine wave in a ping-pong fashion. Initially values for the first buffer are calculated, and then the buffer is handed off to the DMA using a DRV\_CODEC\_BufferAddWrite. While the DMA is transferring data to the SSC or I2SC/I2S peripheral, causing the tone to sent to the codec over I<sup>2</sup>S, the program calculates the values for the next cycle. (In the current version of the program, this is always the same unless the frequency is changed manually.) Then when the DMA callback Audio\_Codec\_BufferEventHandler is called, the second buffer is handed off and the first buffer re-initialized, back and forth.

A table called samples contains the number of samples for each frequency that correspond to one cycle of audio (e.g. 48 for 48000 samples/sec, and 1 kHz tone). This is divided into the MAX\_AUDIO\_NUM\_SAMPLES value (maximum number of elements in the tone) to provide the number of cycles of tone to be generated to fill the table. Another table (appData.numSamples1 or 2) is then filled in with the number of samples for each cycle to be generated. **Note:** the samples table will need to be modified if changing the sample rate to something other than 48000 samples/second.

This table with the number of samples per cycle to be generated is then passed to the function APP\_TONE\_LOOKUP\_TABLE\_Initialize along with which buffer to work with (1 or 2) and the sample rate. The 16-bit value for each sample is calculated based on the relative distance (angle) from 0, based in turn on the current sample number and total number of samples for one cycle. First the angle is calculated in radians:

```
double radians = (M_PI*(double)(360.0/(double)currNumSamples)*(double)i)/180.0;
```

Then the sample value is calculated using the sine function:

```
lookupTable[i].leftData = (int16_t)(0x7FFF*sin(radians));
```

If the number of samples divides into the sample rate evenly, then only 1/4 (90°) of the samples are calculated, and the remainder is filled in by reflection. Otherwise each sample is calculated individually. Before returning, the size of the buffer is calculated based on the number of samples filled in.

## Demonstration Features

- Calculation of a sine wave based on the number of samples and sample rate using the sin function, with reflection if possible
- Uses the Codec Driver Library to write audio samples to the AK4954 or WM8904
- At a lower level, uses the I2S Driver Library between the codec library and the chosen peripheral (SSC or I2SC or I2S) to send the audio to the codec
- Use of ping-pong buffers and DMA
- Use of two timers: one as a periodic 1 ms timer for the application for button debouncing, and a second used by the Codec Driver (see Timer Driver Library)

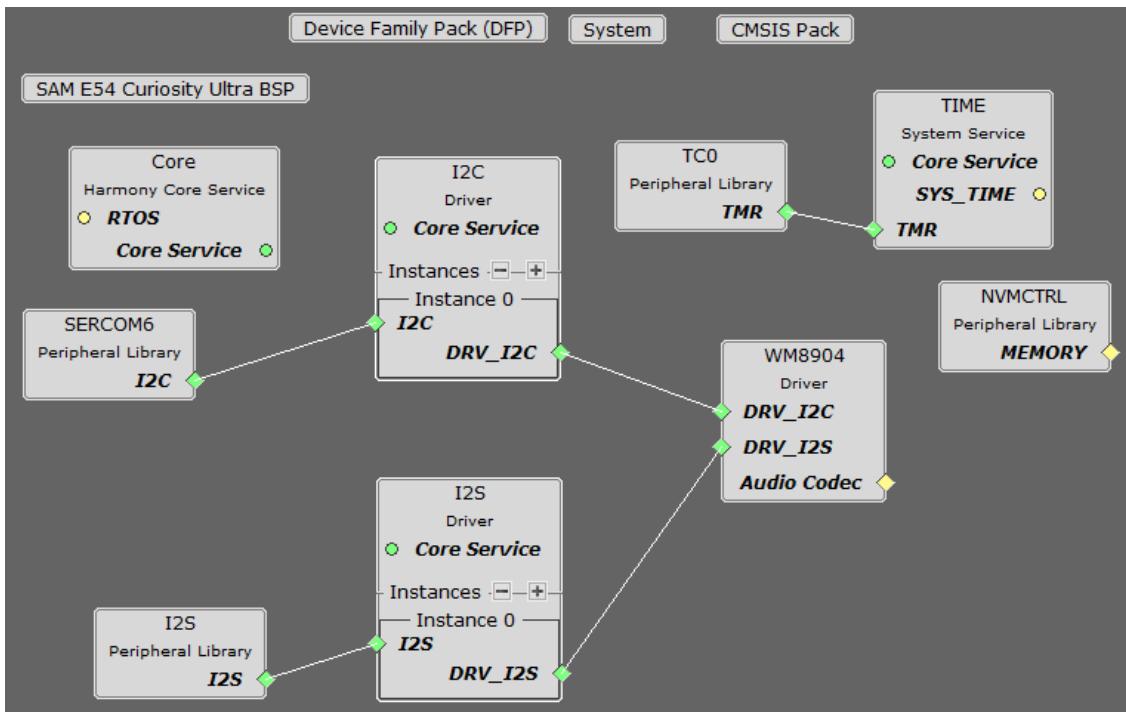
## Tools Setup Differences

For projects using the E54, the I2S interface and the WM8904 as a Master (the WM8904 codec generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP. Select the appropriate processor (ATSAME54P20A). Click Finish.

In the MHC, under Available Components select the BSP SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions. Click on the WM8904 Codec component (*not* the WM8904 Driver). In the Configuration Options, under WM8904 Interface, select I2SC instead of SSC. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes:

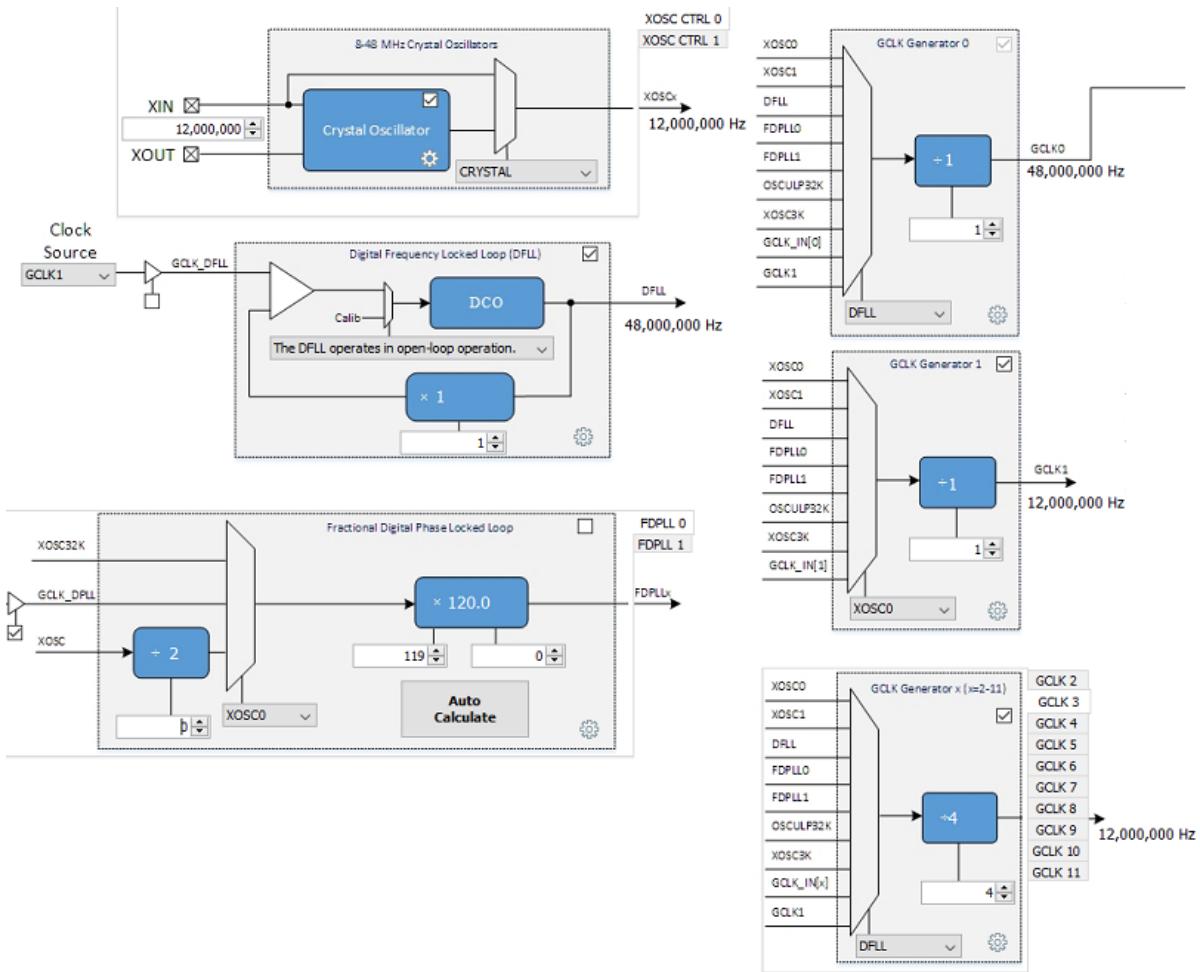


Click on the WM8904 Driver. In the Configurations Options, under Audio Data Format, change it to 32-bit I2S. Set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

In the Clock Diagram:

- Set enable the Crystal Oscillator, change its frequency to 12,000,000 Hz, and select CRYSTAL.
- Uncheck the Fractional Digital Phase Locked Loop enable (FDPLL 0).
- In the CLK Generator 0 box, change the input to DFLL for an output of 48 MHz.
- In the CLK Generator 1 box, change the input to XOSC0 with a divider of 1 for an output of 12 MHz.
- In the GCLK Generator, uncheck the selection for GCLK 2, and then select the GCLK 3 tab. Choose the DFLL as the input, with a divide by 4 for an output of 12 MHz.

You should end up with a clock diagram like this:

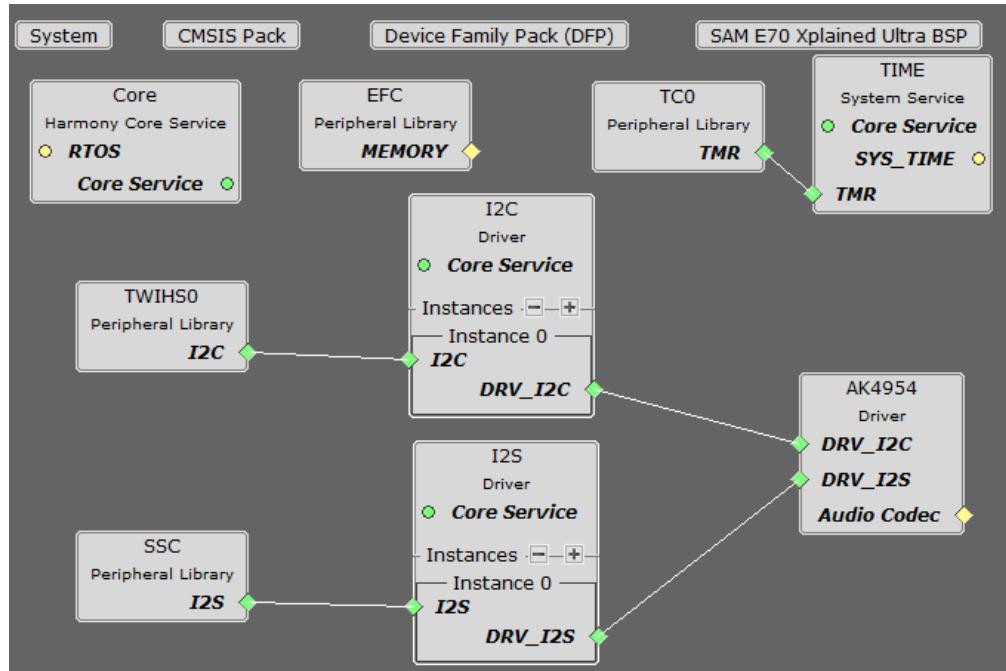


For projects using the E70, the SSC interface and the AK4954 as a Slave (the SAM E70 generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP. Select the appropriate processor (ATSAME70Q21B). Click Finish.

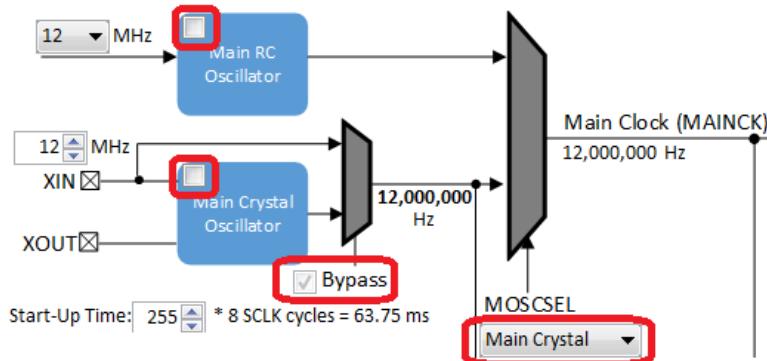
In the MHC, under Available Components select the BSP SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on AK4954 Codec. Answer Yes to all questions. Click on the AK4954 Codec component (*not* the AK4954 Driver). In the Configuration Options, under AK4954 Interface, select I2SC instead of SSC. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes:

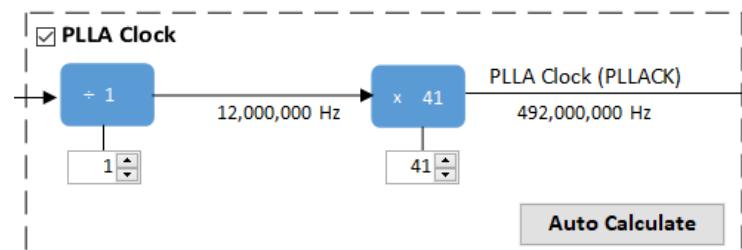


Click on the AK4954 Driver. In the Configurations Options, under Usage Mode, change Master to Slave. Set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

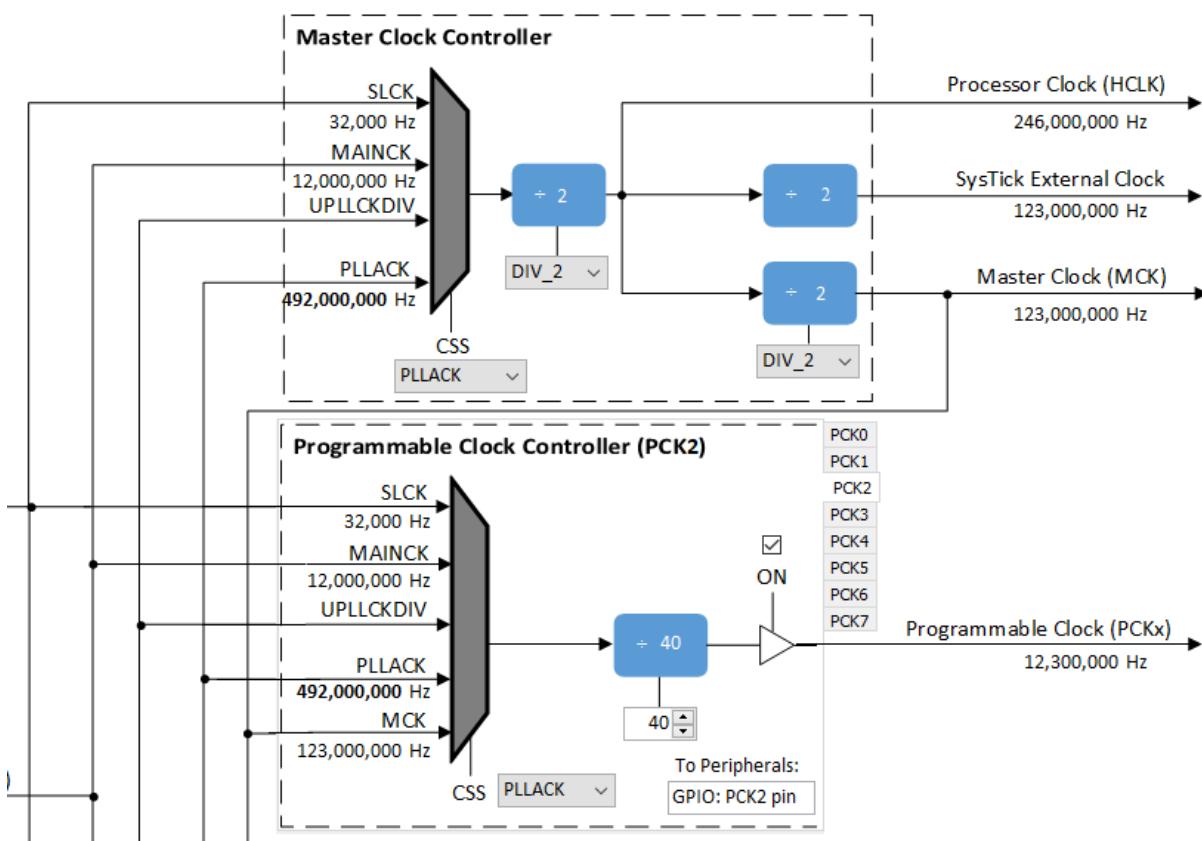
In the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



Still in the Clock Diagram, enable the PLLA Clock. Leave the divider at 1 (12 MHz) and change the multiplier to 41 for an output of 492 MHz.



In the Master Clock Controller, select the source (CSS) as PLLACK (492 MHz), all three dividers as divide by 2 to generate a Processor Clock of 246 MHz and a Master Clock of 123 MHz. In the Programmable Clock Controller section, select the PCK2 tab, select the source (CSS) as PLLACK (492 MHz), the divider of 40 for a PCK2 output of 12,300,000 Hz.



Then check the SSC checkbox in the **Peripheral Clock Controller** section.

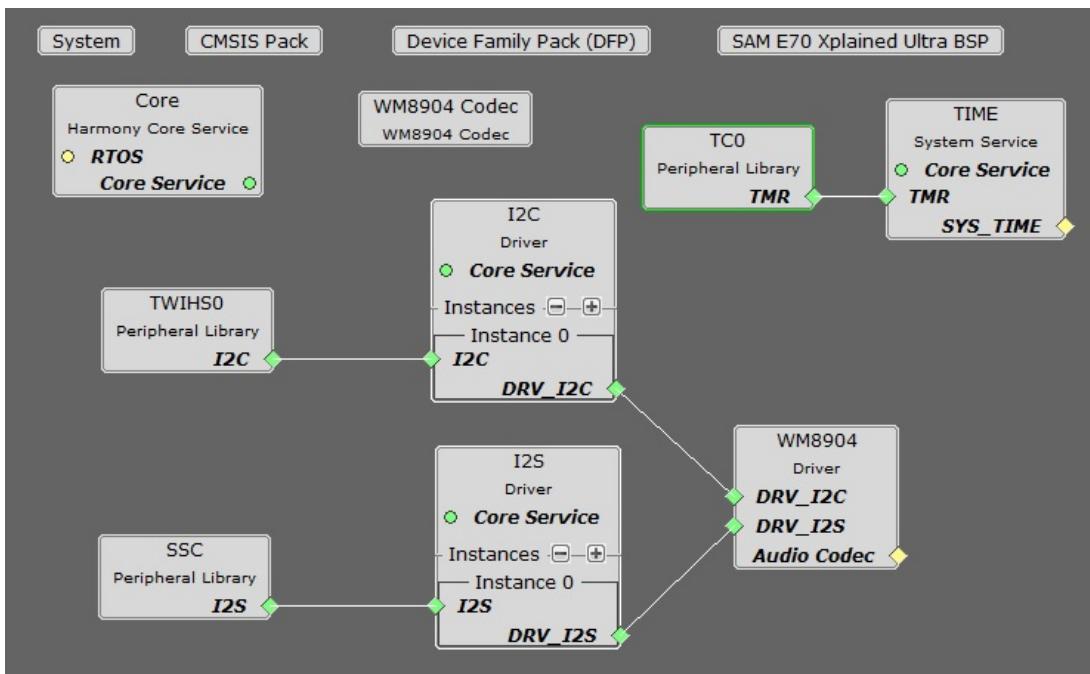
For projects using the E70 or V71, the SSC interface and the WM8904 as a Master (the WM8904 codec generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name the same based on the BSP used. Select the appropriate processor (ATSAME70Q21B or ATSAMV71Q21B) depending on your board. Click Finish.

In the MHC, under Available Components select the appropriate BSP (SAM E70 Xplained Ultra or SAM V71 Xplained Ultra).

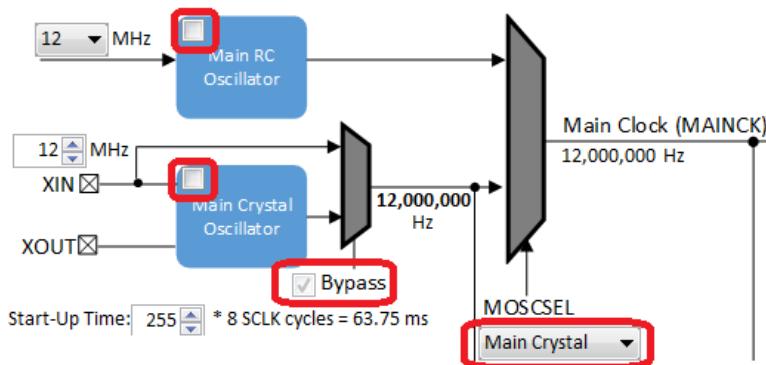
Under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes, assuming a non-FreeRTOS project:



Click on the WM8904 Driver. In the Configurations Options, set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

If using the SAM E70 Xplained Ultra board, in the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



If using the ATSAMV71Q21B, in the Clock Diagram set MOSCEL to Main Crystal, uncheck the Bypass checkbox and RC Crystal Oscillator checkbox, and check the Main Crystal Oscillator box.

Also in the Clock Diagram, in the PCK2 tab of the **Programmable Clock Controller** section, check the On checkbox, and set CSS to MAINCLK (12 MHz). Then check the SSC checkbox in the **Peripheral Clock Controller** section.

It is also possible to change the audio format from 16 to 32-bits, and from I<sup>2</sup>S to Left Justified (SSC only). These changes need to be done in the MHC in both the WM8904, and SSC/I<sup>2</sup>SC Peripherals. In the current application code (app.h), a #define is also set to the current width.

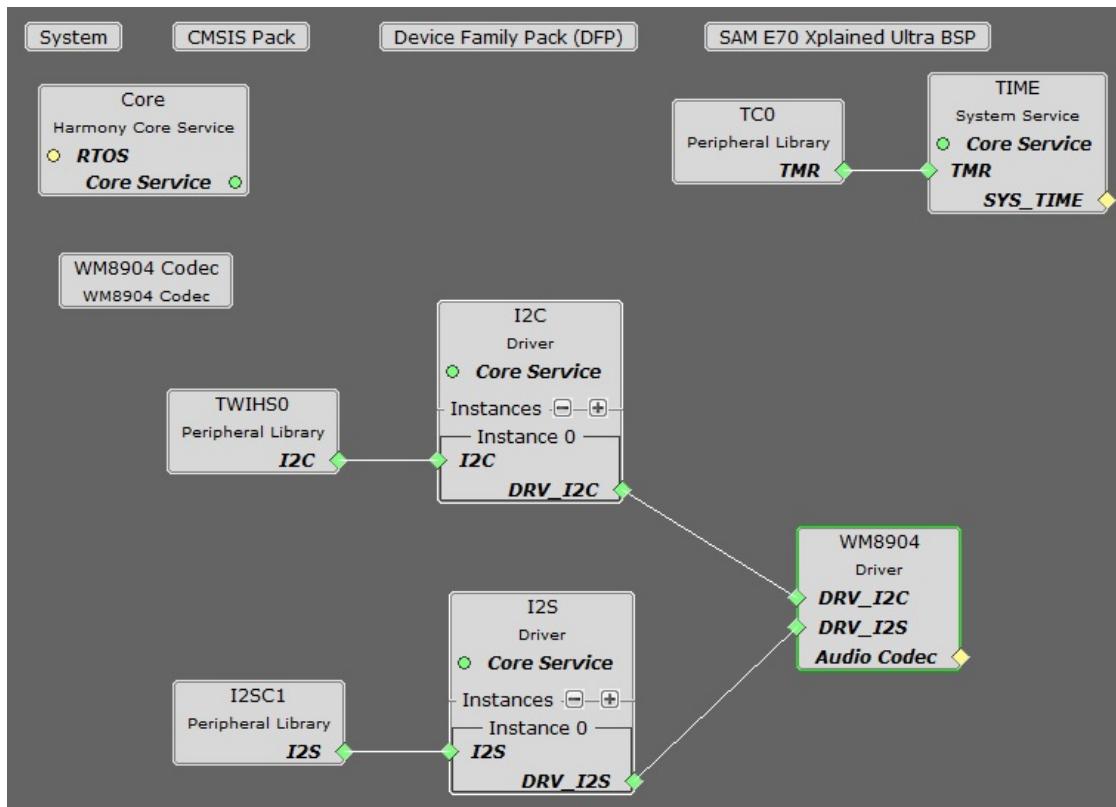
If using FreeRTOS, in the code you will need to move the call to `DRV_WM8904_Tasks(sysObj.drvwm8904Codec0);` from the `SYS_Tasks` function in `src/config/<config_name>/tasks.c` to inside the `while(1)` loop of `_APP_Tasks` (just before the call to `APP_Tasks`).

For projects using the E70, the I<sup>2</sup>SC interface and the WM8904 as a Slave (the SAM E70 generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP. Select the appropriate processor (ATSAME70Q21B). (The WM8904 on the SAM V71 Xplained Ultra cannot be used with I<sup>2</sup>SC.) Click Finish.

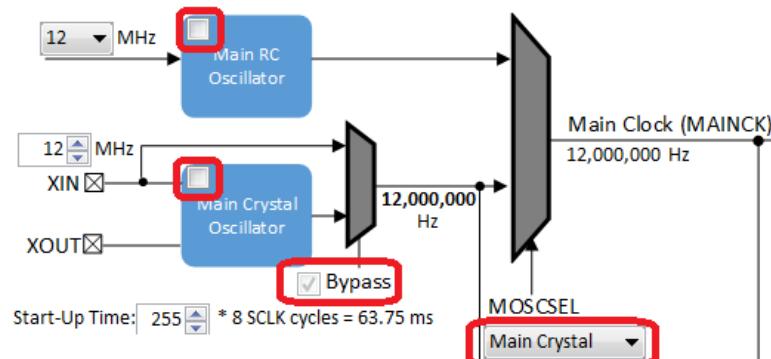
In the MHC, under Available Components select the BSP SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions. Click on the WM8904 Codec component (*not* the WM8904 Driver). In the Configuration Options, under WM8904 Interface, select I<sup>2</sup>SC instead of SSC. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes:



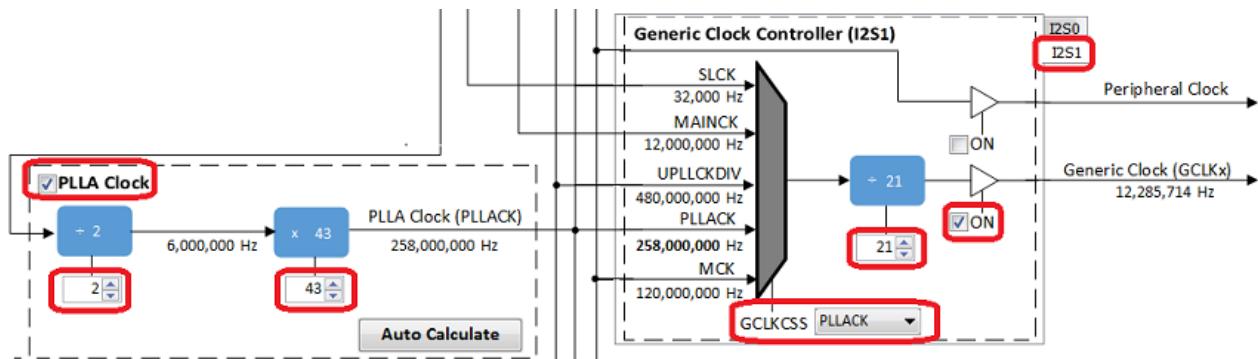
Click on the WM8904 Driver. In the Configurations Options, under Usage Mode, change Master to Slave. Set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

If using the SAM E70 Xplained Ultra board, in the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



Also in the Clock Diagram, in the PCK2 tab of the **Programmable Clock Controller** section, check the On checkbox, and set CSS to MAINCLK (12 MHz).

The following tables show suggested settings for various sample rates in the Clock Diagram when using the I2SC Peripheral in Master mode. Make sure **PLL Clock** checkbox is checked, and fill in the values for the PLLA Multiplier and Divider boxes. Select the I2S1 tab under **Generic Clock Controller**, set GCLKCSS to PLLACK, fill in the Divider value as shown, and check the checkbox next to it.



The values in the first table give the lowest error rate, but have varying PLLACK values so it is best to use the UPPCLKDIV selection for CSS under **Master Clock Controller**, for a Processor Clock of 240 MHz.

Desired Sample Rate	PLLA Multiplier	PLLA Divider	PLLACK	I2SC Generic Clock Divider	Calculated Sample Rate	Error
8000	2	43	258 MHz	126	7998	-0.025%
16000	2	43	258 MHz	63	15997	-0.0187%
44100	1	16	192 MHz	17	41117	0.0385%
48000	2	43	258 MHz	21	47991	-0.0187%
96000	3	43	172 MHz	7	95982	-0.0187%

The values in the second table have somewhat higher error rates, but use a PLLACK value of 294 MHz which is suitable to be used as a Processor Clock (using the PLLACK selection for CSS) which is closer to the maximum of 300 MHz.

Desired Sample Rate	PLLA Multiplier	PLLA Divider	PLLACK	I2SC Generic Clock Divider	Calculated Sample Rate	Error
8000	2	49	294 MHz	144	7975	-0.3125%
16000	2	49	294 MHz	72	15950	-0.3125%
44100	2	49	294 MHz	26	41170	0.1587%
48000	2	49	294 MHz	24	47851	-0.3104%
96000	3	49	294 MHz	12	95703	-0.3094%

It is also possible to change the audio format from 16 to 32-bits. This changes need to be done in the MHC in both the WM8904 Driver and I2SC Peripheral. In the current application code (app.h), a #define is also set to the current width.

If using FreeRTOS, in the code you will need to move the call to `DRV_WM8904_Tasks(sysObj.drvwm8904Codec0);` from the `SYS_Tasks` function in `src/config/<config_name>/tasks.c` to inside the `while(1)` loop of `_APP_Tasks` (just before the call to `APP_Tasks`).

## Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

## Description

The parent folder for these files is `audio/apps/audio_tone`. To build this project, you must open the `audio/apps/audio_tone/firmware/*.x` project file in MPLAB X IDE that corresponds to your hardware configuration.

## MPLAB X IDE Project Configurations

The following table lists and describes supported project configurations.

Project Name	BSP Used	Description
audio_tone_sam_e54_cult_wm8904_ssc	sam_e54_cult	This demonstration runs on the ATSAME54P20A processor on the SAM E54 Curiosity Ultra board and the WM8904 Audio Codec Daughter Board. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave.
audio_tone_sam_e54_cult_wm8904_ssc_freertos	sam_e54_cult	This demonstration runs on the ATSAME54P20A processor on the SAM E54 Curiosity Ultra board and the WM8904 Audio Codec Daughter Board. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave. This demonstration also uses FreeRTOS.
audio_tone_sam_e70_xult_ak4954_ssc	sam_e70_xult	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the AK4954 Audio Codec Daughter Board. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The AK4954 codec is configured as the slave, and the SSC peripheral as the master.
audio_tone_sam_e70_xult_wm8904_ssc	sam_e70_xult	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave.
audio_tone_sam_e70_xult_wm8904_ssc_freertos	sam_e70_xult	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave. This demonstration also uses FreeRTOS.
audio_tone_sam_e70_xult_wm8904_i2sc	sam_e70_xult	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the I2SC PLIB. The WM8904 codec is configured as the slave, and the I2SC peripheral as the master.
audio_tone_sam_v71_xult	sam_v71_xult	This demonstration runs on the ATSAMV71Q21B processor on the SAM V71 Xplained Ultra board along with the on-board WM8904 codec. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave.

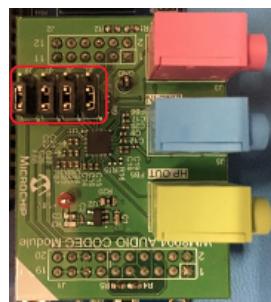
## Configuring the Hardware

This section describes how to configure the supported hardware.

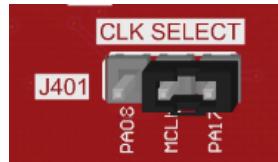
### Description

Using the SAM E54 Curiosity Ultra board and the WM8904 Audio Codec Daughter Board, and the SSC PLIB. All jumpers on the

WM8904 should be toward the **front**:



In addition, make sure the J401 jumper (CLK SELECT) is set for the PA17 pin:

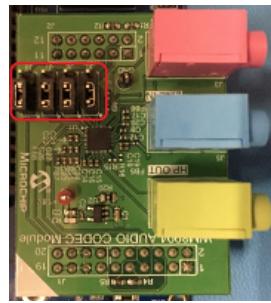


- **Note:** The SAM E54 Curiosity Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

Using the SAM E70 Xplained Ultra board and the AK4954 Audio Codec Daughter Board, and the SSC PLIB. No special configuration needed.

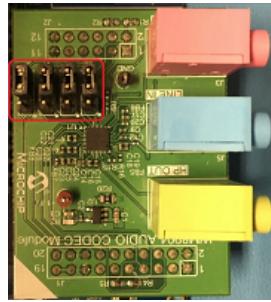
- **Note:** The SAM E70 Xplained Ultra board does not include the AK4954 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC324954.

Using the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, and the SSC PLIB. All jumpers on the WM8904 should be toward the **front**:



- **Note:** The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

Using the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, and the I2SC PLIB. All jumpers on the WM8904 should be toward the **back**:



- **Note:** The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

Using the SAM V71 Xplained Ultra board with on-board WM8904, with the SSC PLIB. No special configuration needed.

## Running the Demonstration

This section demonstrates how to run the demonstration.

### Description

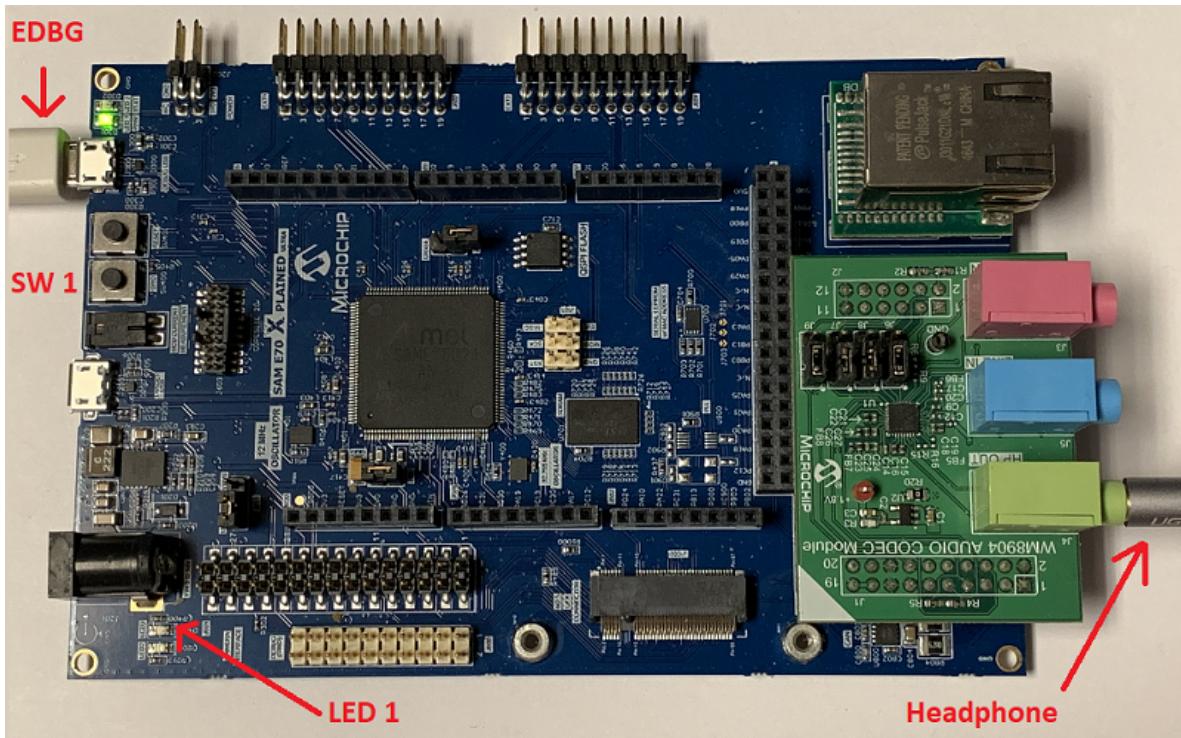
**Important!** Prior to using this demonstration, it is recommended to review the MPLAB Harmony 3 Release Notes for any known issues.

All configurations:

Continuous sine tones of four frequencies can be generated. **Table 1** provides a summary of the button actions that can be used to control the volume and frequency.

Compile the program using MPLAB X, and program the target device using the EDBG interface. While compiling, select the appropriate MPLAB X IDE project. Refer to [Building the Application](#) for details.

1. Connect headphones to the HP OUT jack of the AK4954 or WM8904 Audio Codec Daughter Board (see **Figure 1**), or the HEADPHONE jack of the SAM V71 Xplained Ultra board.
2. The tone can be quite loud, especially when using a pair of headphones.
3. Initially the program will be in volume-setting mode (LED1 off) at a medium volume setting. Pressing SW1 with LED1 off will cycle through four volume settings (including mute).
4. Pressing SW1 longer than one second will change to frequency-setting mode (LED1 on). Pressing SW1 with LED1 on will cycle through four frequency settings -- 250 Hz, 500 Hz, 1 kHz, and 2 kHz.
5. Pressing SW1 longer than one second again will switch back to volume-setting mode again (LED1 off).



**Figure 1: WM8904 Audio Codec Daughter Board on SAM E70 Xplained Ultra board**

### Control Descriptions

**Table 1: Button Controls for SAM E54 Curiosity Ultra board, SAM E70 Xplained Ultra board and SAM V71 Xplained Ultra board**

Control	Description
SW1 short press	If LED1 is off, SW1 cycles through four volume levels (one muted). If LED1 is on, SW1 cycles through four frequencies of sine tone.
SW1 long press (> 1 second)	Alternates between modes (LED1 on or off).

## audio\_tone\_linkeddma

This topic provides instructions and information about the MPLAB Harmony 3 Audio Tone using Linked DMA demonstration application, which is included in the MPLAB Harmony Library distribution.

### Description

In this demonstration application the Codec Driver sets up the WM8904 Codec. The demonstration sends out generated audio waveforms (sine tone) using linked DMA channels with volume and frequency modifiable through the on-board push button. Success is indicated by an audible output corresponding to displayed parameters.

The sine tone is one of four frequencies: 250 Hz, 500 Hz, 1 kHz, and 2 kHz, sent by default at 48,000 samples/second, which is modifiable in the MHC as described below.

To know more about the MPLAB Harmony Codec Drivers, configuring the Codec Drivers, and the APIs provided by the Codec Drivers, refer to Codec Driver Libraries.

### Architecture

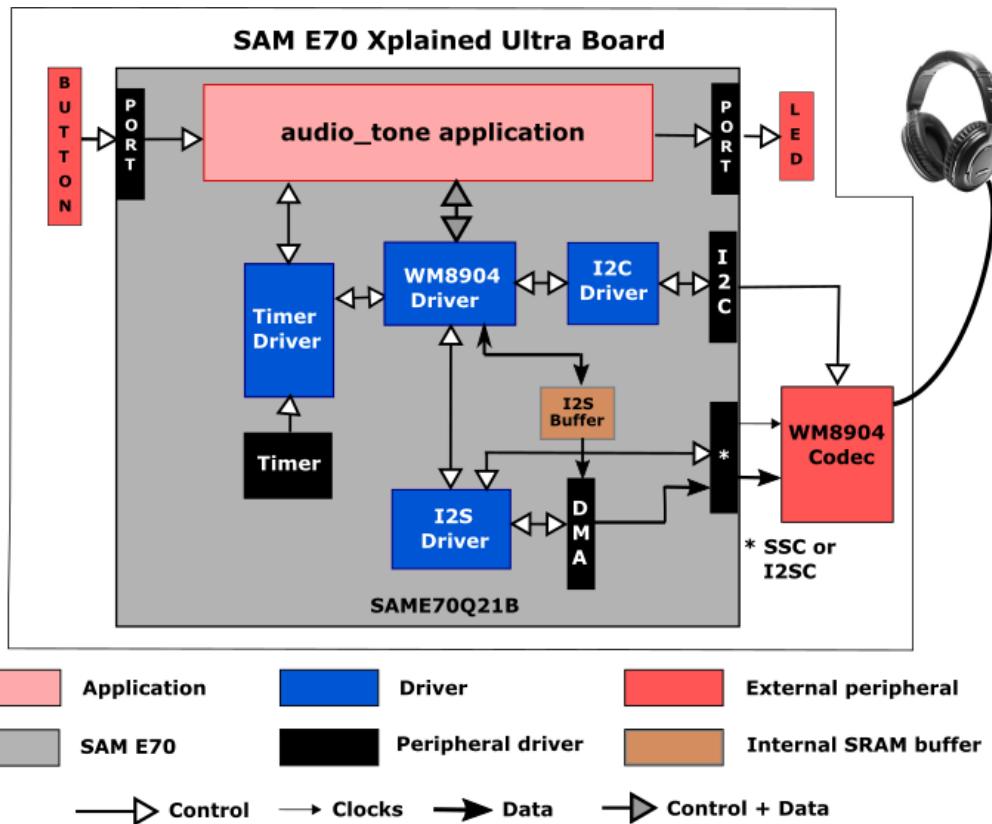
The two projects run on the SAM E70 Xplained Ultra Board, which contains a ATSAME70Q21B microcontroller with 2 MB of Flash memory and 384 KB of RAM running at 300 MHz using the following features:

- One push button (SW1)
- Two LEDs (LED1 and 2)
- WM8904 Codec Daughter Board mounted on a X32 socket

The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

The program takes up to approximately 1% (17 KB) of the ATSAME70Q21B microcontroller's program space. The 16-bit configuration uses 2% (6 KB) of the RAM. No heap is used.

The following figure illustrates the application architecture for the two SAM E70 Xplained Ultra configurations:



Depending on the project, either the SSC (Synchronous Serial Controller) or I2SC (Inter-IC Sound Controller) is used with the WM8904 codec, selected by a strapping option on the WM8904 daughterboard. When using the SSC interface, the WM8904 is configured in master mode, meaning it generates the I<sup>2</sup>S clocks (LRCLK and BCLK), and the SSC peripheral is configured as a slave. When using the I2SC interface, the WM8904 is configured in slave mode and the SSC peripheral is a master and generates the I2SC clocks. The other two possibilities (SSC as master and WM8904 as slave, or I2SC as slave and WM8904 as master) are possible, but not discussed.

The same application code is used without change between the two projects.

The SAM E70/SAM V71 microcontroller (MCU) runs the application code, and communicates with the WM8904 codec via an I<sup>2</sup>C interface. The audio interface between the SAM E70/V71 and the WM8904 codec use the I<sup>2</sup>S interface. Audio is configured as 16-bit, 48,000 samples/second, I<sup>2</sup>S format. (16-bit, 48 kHz is the standard rate used for DVD audio. An alternate that could be used is 44,100 samples/second. This is the same sample rate used for CD's. The sample rate is configurable in the MHC.)

The Master Clock (MCLK) signal used by the codec is generated by the Peripheral Clock section of the SAM E70/V71, and is fixed at 12 MHz.

The button and LEDs are interfaced using GPIO pins. There is no screen.

As with any MPLAB Harmony application, the `SYS_Initialize` function, which is located in the `initialization.c` source file, makes calls to initialize various subsystems as needed, such as the clock, ports, board support package (BSP), WM8904 codec, I2S, I2C, DMA, timers, and interrupts.

The codec driver and the application state machines are all updated through calls located in the `SYS_Tasks` function in the `tasks.c` file.

The application code is contained in the several source files. The application's state machine (`APP_Tasks`) is contained in `app.c`. It first initializes the application, which includes `APP_Tasks` then periodically calls `APP_Button_Tasks` to process any pending button presses.

Then the application state machine inside `APP_Tasks` is given control, which first gets a handle to a timer driver instance and sets up a periodic (alarm) callback. In the next state it gets a handle to the codec driver by calling the `DRV_CODEC_Open` function with a mode of `DRV_IO_INTENT_WRITE` and sets up the volume.

The application state machine then registers an event handler `APP_CODEC_BufferEventHandler` as a callback with the codec driver (which in turn is called by the DMA driver).

Two buffers are used for generating a sine wave. Each contains the data for one cycle of audio. One is currently output on a repeated basis, and the second is filled in as necessary when the frequency changes. Then it is designated as the output buffer.

Initially, values for both buffers are calculated in advance. Two calls to the function `DRV_I2S_InitWriteLinkedListTransfer` are made each passing the address of one buffer. The buffers are each linked back to themselves such that when one is done, it starts over again. A call to `DRV_I2S_StartWriteLinkedListTransfer` is made, which starts the DMA sending data from the first buffer to the codec.

Only when the frequency is changed, due to a button press, does the second buffer come into play. In that case new values are calculated for the second buffer (while the first buffer continues to be used for output). When the second buffer has been filled in, a call is made to `DRV_I2S_WriteNextLinkedListTransfer` which transfers control to the second buffer after the first buffer finishes. The way the pointers are set up, it will then repeat on itself until another frequency change is made, and after which control will revert back to the first buffer.

A table called `samples` contains the number of samples for each frequency that correspond to one cycle of audio (e.g. 48 for 48000 samples/sec, and a 1 kHz tone). **Note:** the `samples` table will need to be modified if changing the sample rate to something other than 48000 samples/second.

This value with the number of samples to be generated is then passed to the function `APP_TONE_LOOKUP_TABLE_Initialize` along with which buffer to work with (1 or 2) and the sample rate. The 16-bit value for each sample is calculated based on the relative distance (angle) from 0, based in turn on the current sample number and total number of samples for one cycle. First the angle is calculated in radians:

```
double radians = (M_PI*(double)(360.0/(double)currNumSamples)*(double)i)/180.0;
```

Then the sample value is calculated using the sine function:

```
lookupTable[i].leftData = (int16_t)(0x7FFF*sin(radians));
```

If the number of samples divides into the sample rate evenly, then only 1/4 (90°) of the samples are calculated, and the remainder is filled in by reflection. Otherwise each sample is calculated individually. Before returning, the size of the buffer is calculated based on the number of samples filled in.

## Demonstration Features

- Calculation of a sine wave based on the number of samples and sample rate using the sin function
- Uses the Codec Driver Library to write audio samples to the WM8904
- At a lower level, uses the I2S Driver Library between the codec library and the chosen peripheral (SSC or I2SC) to send the audio to the codec
- Use of alternate buffers (one active, one standby) and linked DMA
- Use of two timers: one as a periodic 1 ms timer for the application for button debouncing, and a second used by the Codec Driver (see Timer Driver Library)

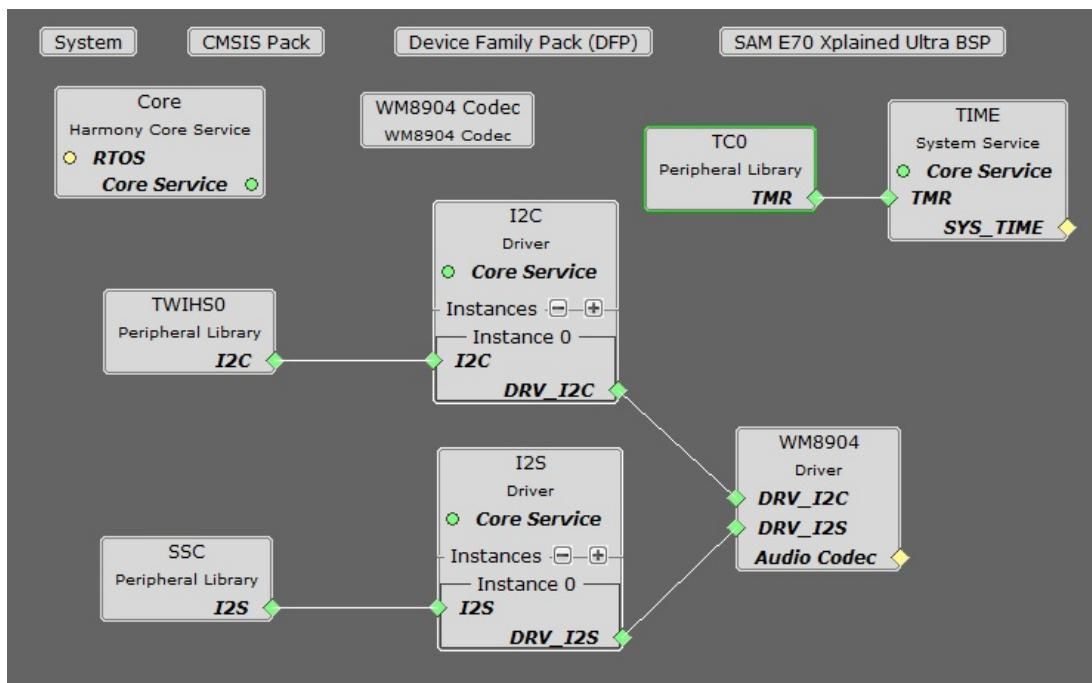
## Tools Setup Differences

For projects using the SSC interface and the WM8904 as a Master (the WM8904 codec generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name the same based on the BSP used. Select the appropriate processor (ATSAME70Q21B or ATSAMV71Q21B) depending on your board. Click Finish.

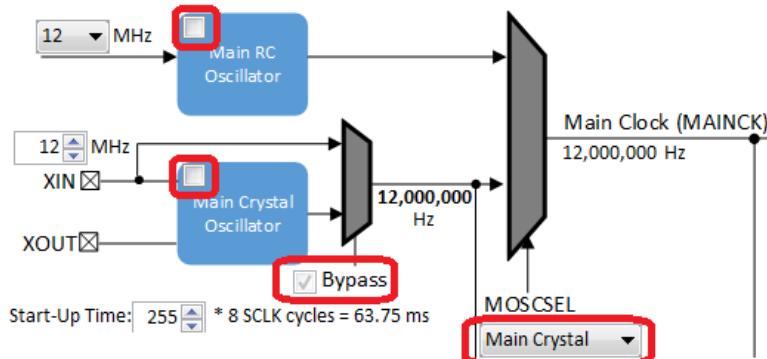
In the MHC, under Available Components select the appropriate BSP (SAM E70 Xplained Ultra or SAM V71 Xplained Ultra). Under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes, assuming a non-FreeRTOS project:



Click on the WM8904 Driver. In the Configurations Options, set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

If using the SAM E70 Xplained Ultra board, in the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



If using the ATSAMV71Q21B, in the Clock Diagram set MOSCEL to Main Crystal, uncheck the Bypass checkbox and RC Crystal Oscillator checkbox, and check the Main Crystal Oscillator box.

Also in the Clock Diagram, in the PCK2 tab of the **Programmable Clock Controller** section, check the On checkbox, and set CSS to MAINCLK (12 MHz). Then check the SSC checkbox in the **Peripheral Clock Controller** section.

It is also possible to change the audio format from 16 to 32-bits, and from I2S to Left Justified (SSC only). These changes need to be done in the MHC in both the WM8904, and SSC/I2SC Peripherals. In the current application code (app.h), a #define is also set to the current width.

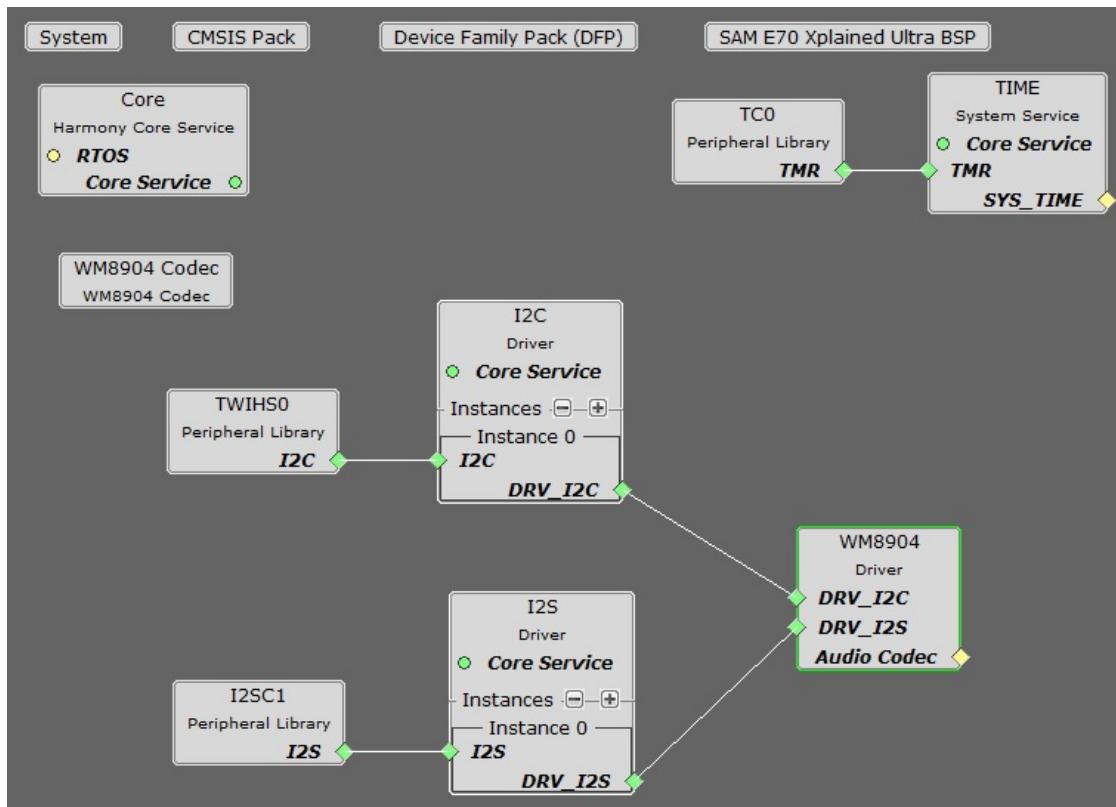
If using FreeRTOS, in the code you will need to move the call to `DRV_WM8904_Tasks(sysObj.drvwm8904Codec0);` from the `SYS_Tasks` function in `src/config/<config_name>/tasks.c` to inside the `while(1)` loop of `_APP_Tasks` (just before the call to `APP_Tasks`).

For projects using the I2SC interface and the WM8904 as a Slave (the SAM E70 generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP. Select the appropriate processor (ATSAME70Q21B). (The WM8904 on the SAM V71 Xplained Ultra cannot be used with I2SC.) Click Finish.

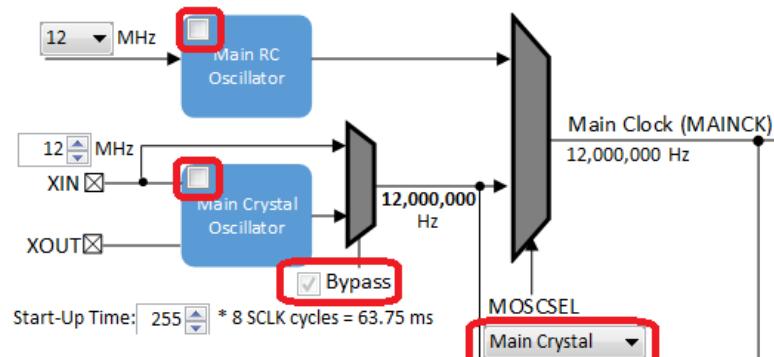
In the MHC, under Available Components select the BSP SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions. Click on the WM8904 Codec component (*not* the WM8904 Driver). In the Configuration Options, under WM8904 Interface, select I2SC instead of SSC. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes, assuming a non-FreeRTOS project:



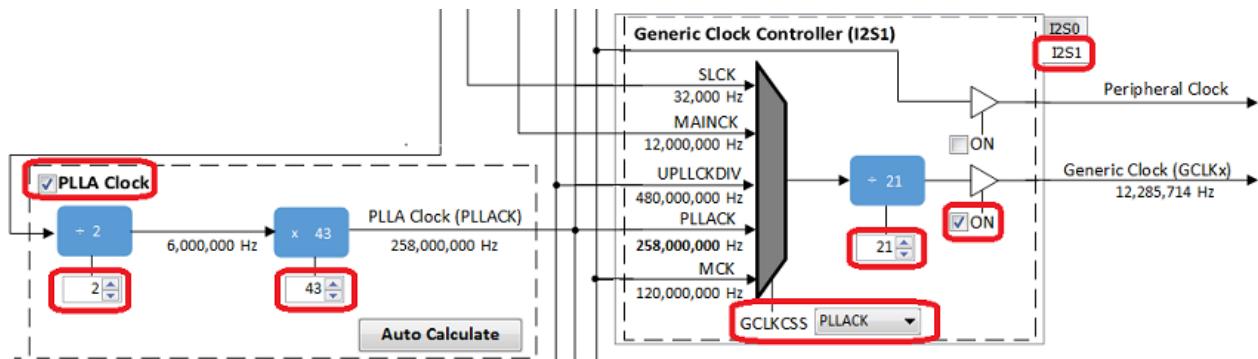
Click on the WM8904 Driver. In the Configurations Options, under Usage Mode, change Master to Slave. Set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

If using the SAM E70 Xplained Ultra board, in the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



Also in the Clock Diagram, in the PCK2 tab of the **Programmable Clock Controller** section, check the On checkbox, and set CSS to MAINCLK (12 MHz).

The following tables show suggested settings for various sample rates in the Clock Diagram when using the I2SC Peripheral in Master mode. Make sure **PLLAC Clock** checkbox is checked, and fill in the values for the PLLA Multiplier and Divider boxes. Select the I2S1 tab under **Generic Clock Controller**, set GCLKCSS to PLLACK, fill in the Divider value as shown, and check the checkbox next to it.



The values in the first table give the lowest error rate, but have varying PLLACK values so it is best to use the UPPCLKDIV selection for CSS under **Master Clock Controller**, for a Processor Clock of 240 MHz.

Desired Sample Rate	PLLA Multiplier	PLLA Divider	PLLACK	I2SC Generic Clock Divider	Calculated Sample Rate	Error
8000	2	43	258 MHz	126	7998	-0.025%
16000	2	43	258 MHz	63	15997	-0.0187%
44100	1	16	192 MHz	17	41117	0.0385%
48000	2	43	258 MHz	21	47991	-0.0187%
96000	3	43	172 MHz	7	95982	-0.0187%

The values in the second table have somewhat higher error rates, but use a PLLACK value of 294 MHz which is suitable to be used as a Processor Clock (using the PLLACK selection for CSS) which is closer to the maximum of 300 MHz.

Desired Sample Rate	PLLA Multiplier	PLLA Divider	PLLACK	I2SC Generic Clock Divider	Calculated Sample Rate	Error
8000	2	49	294 MHz	144	7975	-0.3125%
16000	2	49	294 MHz	72	15950	-0.3125%
44100	2	49	294 MHz	26	41170	0.1587%
48000	2	49	294 MHz	24	47851	-0.3104%
96000	3	49	294 MHz	12	95703	-0.3094%

It is also possible to change the audio format from 16 to 32-bits. This changes need to be done in the MHC in both the WM8904 Driver and SSC Peripheral. In the current application code (app.h), a #define is also set to the current width.

If using FreeRTOS, in the code you will need to move the call to `DRV_WM8904_Tasks`(sysObj.drvwm8904Codec0); from the `SYS_Tasks` function in `src/config/<config_name>/tasks.c` to inside the `while(1)` loop of `_APP_Tasks` (just before the call to `APP_Tasks`).

## Bulding the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

## Description

The parent folder for these files is `audio/apps/audio_tone_linkeddma`. To build this project, you must open the `audio/apps/audio_tone_linkeddma/firmware/*.X` project file in MPLAB X IDE that corresponds to your hardware configuration.

### MPLAB X IDE Project Configurations

The following table lists and describes supported configurations.

Project Name	BSP Used	Description
audio_tone_ld_sam_e70_xult_wm8904_ssc	sam_e70_xult	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, using linked DMA. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave.
audio_tone_ld_sam_e70_xult_wm8904_i2sc	sam_e70_xult	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, using linked DMA. The project configuration is for a sine tone with 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the I2SC PLIB. The WM8904 codec is configured as the slave, and the I2SC peripheral as the master.

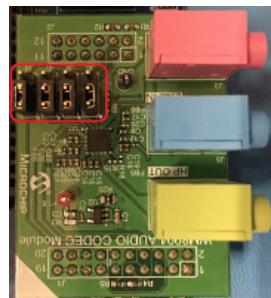
## Configuring the Hardware

This section describes how to configure the supported hardware.

### Description

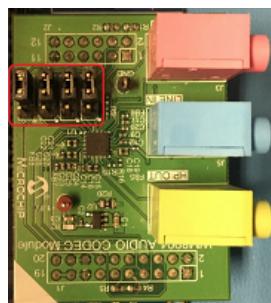
Using the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, with the SSC PLIB:

All jumpers on the WM8904 should be toward the **front**.



Using the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, with the I2SC PLIB:

All jumpers on the WM8904 should be toward the **back**.



- **Note:** The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

## Running the Demonstration

This section demonstrates how to run the demonstration.

## Description

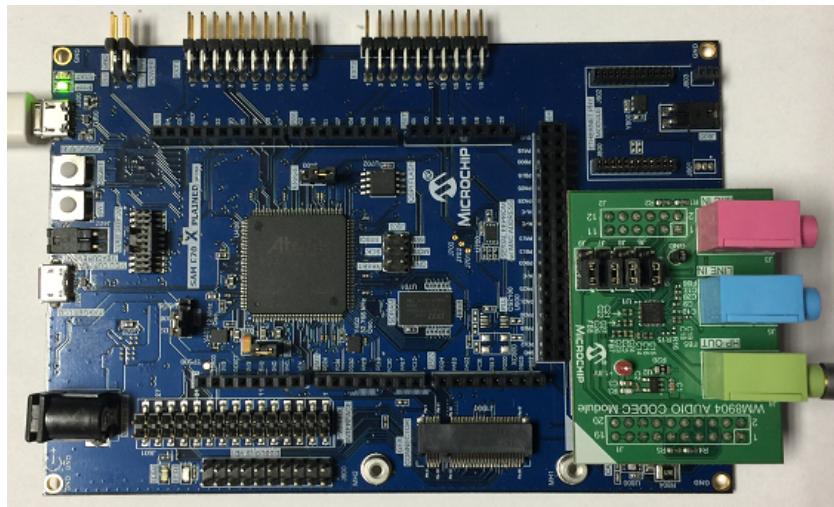
**Important!** Prior to using this demonstration, it is recommended to review the MPLAB Harmony 3 Release Notes for any known issues.

All configurations:

Continuous sine tones of four frequencies can be generated. **Table 1** provides a summary of the button actions that can be used to control the volume and frequency.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project based. Refer to Building the Applications for details.

1. Connect headphones to the HP OUT jack of the WM8904 Audio Codec Daughter Board (see **Figure 1**).
2. The tone can be quite loud, especially when using a pair of headphones.
3. Initially the program will be in volume-setting mode (LED1 off) at a medium volume setting. Pressing SW1 with LED1 off will cycle through four volume settings (including mute).
4. Pressing SW1 longer than one second will change to frequency-setting mode (LED1 on). Pressing SW1 with LED1 on will cycle through four frequency settings -- 250 Hz, 500 Hz, 1 kHz, and 2 kHz.
5. Pressing SW1 longer than one second again will switch back to volume-setting mode again (LED1 off).



**Figure 1: WM8904 Audio Codec Daughter Board on SAM E70 Xplained Ultra board**

## Control Descriptions

**Table 1: Button Controls for SAM E70 Xplained Ultra board**

Control	Description
SW1 short press	If LED1 is off, SW1 cycles through four volume levels (one muted). If LED1 is on, SW1 cycles through four frequencies of sine tone.
SW1 long press (> 1 second)	Alternates between modes (LED1 on or off).

## microphone\_loopback

This topic provides instructions and information about the MPLAB Harmony 3 Microphone Loopback demonstration application, which is included in the MPLAB Harmony Library distribution.

## Description

In this demonstration application, the WM8904 Codec Driver sets up the codec so it can receive audio data through the microphone input on the daughter board and sends this same audio data back out through the on-board headphones, after a delay. The volume and delay are configurable using the on-board pushbutton. The audio by default is sampled at 48,000 samples/second, which is modifiable in the MHC as described below.

To know more about the MPLAB Harmony Codec Drivers, configuring the Codec Drivers, and the APIs provided by the Codec Drivers, refer to Codec Driver Libraries.

## Architecture

There are seven different projects packaged in this application.

### SAM E54 Curiosity Ultra Projects:

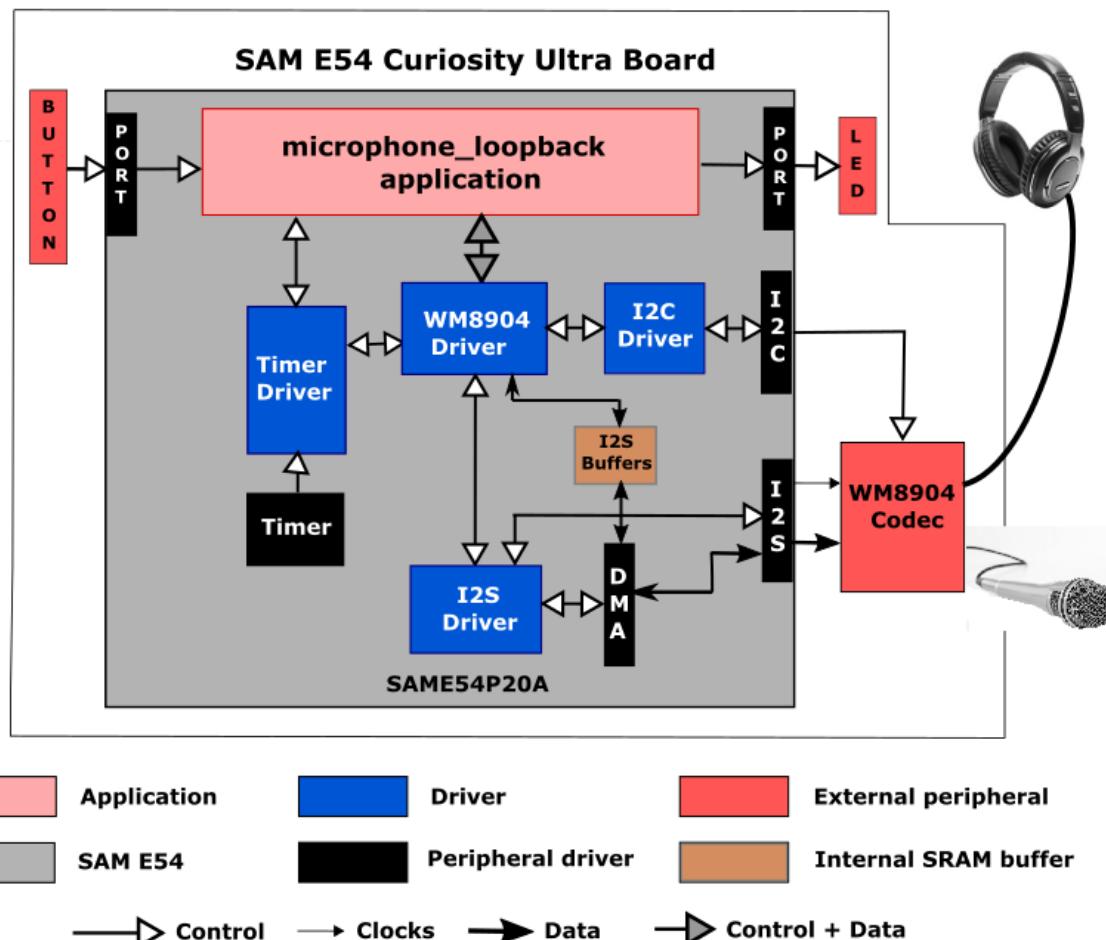
Two projects run on the SAM E54 Curiosity Ultra Board, which contains a ATSAME54P20A microcontroller with 1 MB of Flash memory and 256 KB of RAM running at 48 MHz using the following features:

- Two push buttons (SW1 and SW2)
- Two LEDs (LED1 and 2)
- WM8904 Codec Daughter Board mounted on a X32 socket

The SAM E54 Curiosity Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

The non-RTOS version of the program takes up to approximately 2% (23 KB) of the ATSAME54P20A microcontroller's program space. The 16-bit configuration uses 45% (115 KB) of the RAM. No heap is used. For the FreeRTOS project, the program takes up to approximately 3% (31 KB) of the ATSAME54P20A microcontroller's program space, and the 16-bit configuration uses 60% (155 KB) of the RAM. No heap is used.

The following figure illustrates the application architecture for the two SAM E54 Xplained Ultra configurations (RTOS not shown):



The I<sup>2</sup>S (Inter-IC Sound Controller) is used with the WM8904 codec. The WM8904 is configured in master mode, meaning it generates the I<sup>2</sup>S clocks (LRCLK and BCLK), and the I<sup>2</sup>S peripheral is configured as a slave.

#### SAM E70 Xplained Ultra Projects (no display):

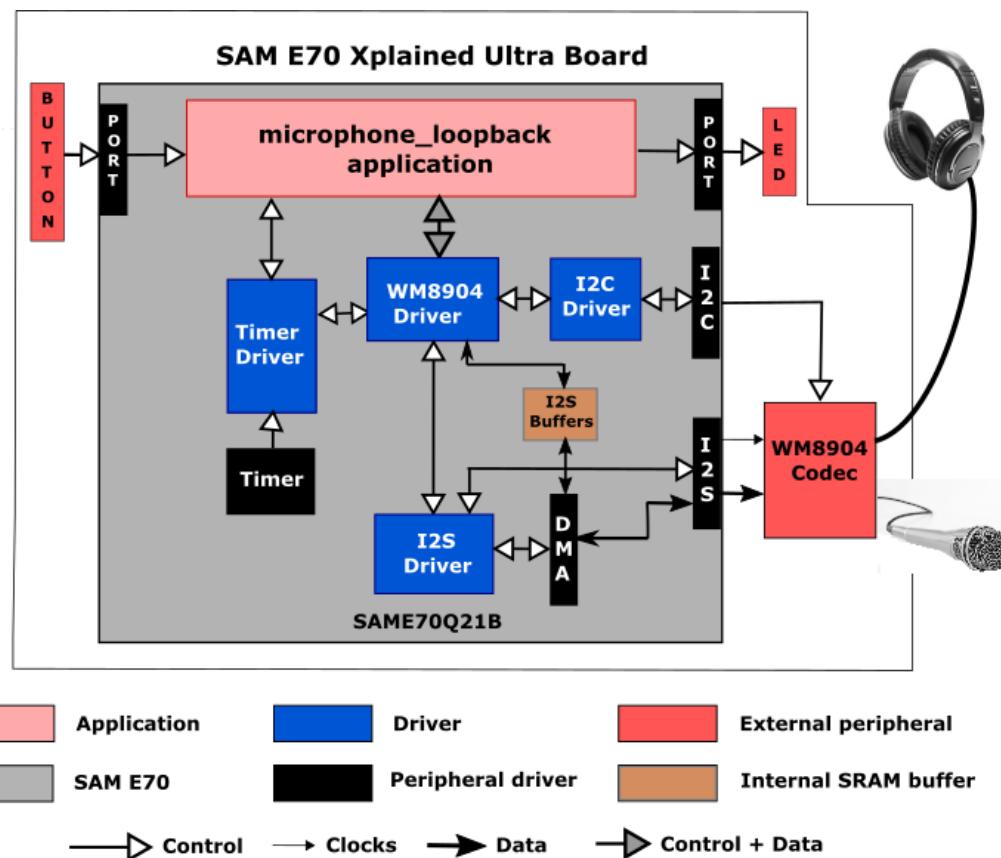
Three projects run on the SAM E70 Xplained Ultra Board without a display, which contains a ATSAME70Q21B microcontroller with 2 MB of Flash memory and 384 KB of RAM running at 300 MHz using the following features:

- One push button (SW1, may be labeled as SW0 on some boards)
- Two LEDs (LED1 and 2)
- AK4954 or WM8904 Codec Daughter Board mounted on a X32 socket

The SAM E70 Xplained Ultra board does not include the AK4954 or WM8904 Audio Codec daughterboards, which are sold separately on microchipDIRECT as part numbers AC324954 and AC328904, respectively.

The two non-RTOS versions of the program take up to approximately 1% (18 KB) of the ATSAME70Q21B microcontroller's program space. The 16-bit configuration uses 30% (115 KB) of the RAM. No heap is used. For the FreeRTOS project, the program takes up to approximately 1% (22 KB) of the ATSAME70Q21B microcontroller's program space, and the 16-bit configuration uses 41% (155 KB) of the RAM. No heap is used.

The following figure illustrates the application architecture for the three SAM E70 Xplained Ultra configurations using the WM8904 (RTOS not shown). The AK4954 version is the same with the substitution of the AK4954 Driver and Codec blocks.



The I<sup>2</sup>SC (Inter-IC Sound Controller) is used with the WM8904 codec, selected by a strapping option on the WM8904 daughterboard. The WM8904 is configured in slave mode and the I<sup>2</sup>SC peripheral is a master and generates the I<sup>2</sup>SC (LRCLK and BCLK) clocks. Other possible configurations are possible but not discussed.

#### SAM E70 Xplained Ultra Project with LCD display:

This project runs on the SAM E70 Xplained Ultra Board, which contains a ATSAME70Q21B microcontroller with 2 MB of Flash memory and 384 KB of RAM running at 300 MHz using the following features:

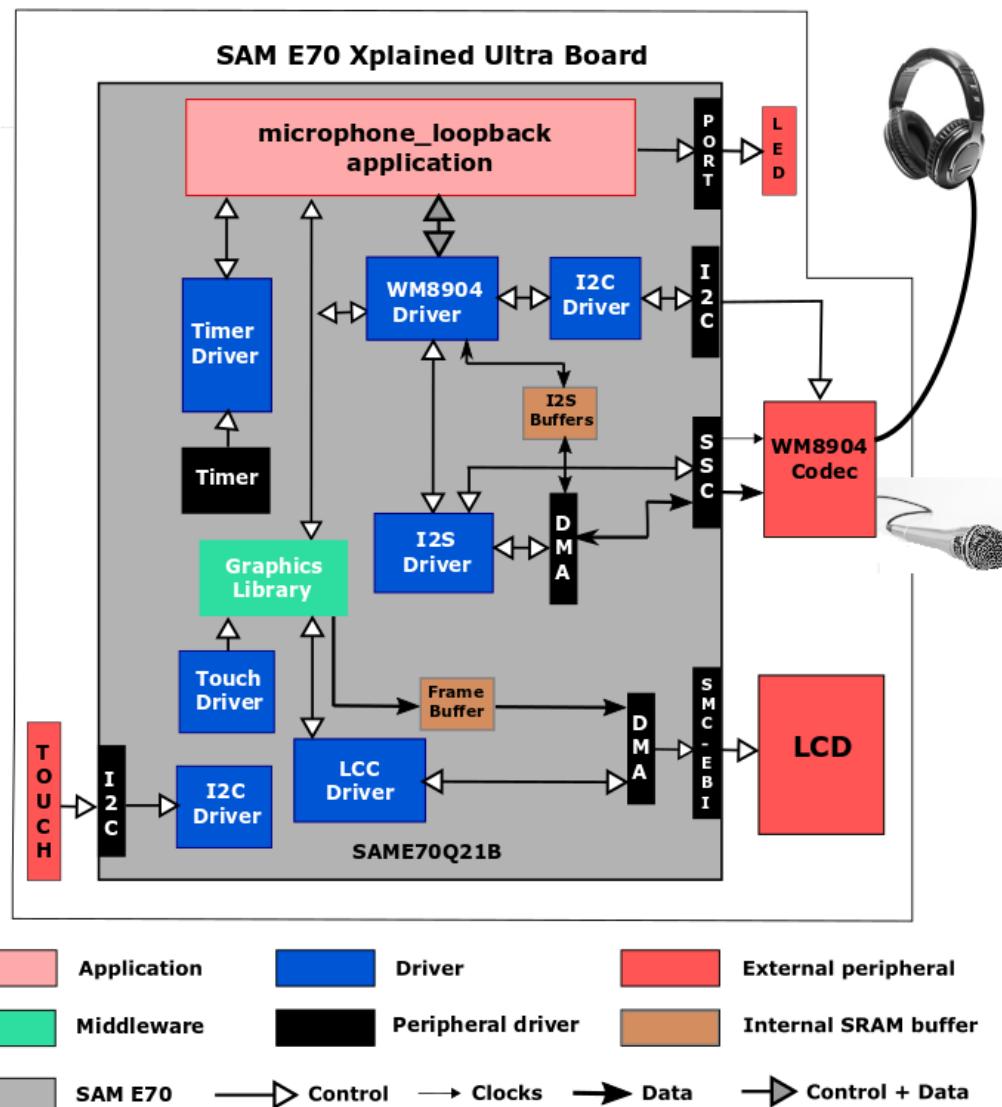
- WM8904 Codec Daughter Board mounted on a X32 socket
- PDA TM4301B 480x272 (WQVGA) Display

The SAM E70 Xplained Ultra board does not include either the WM8904 Audio Codec daughterboard or the TM4301B graphics card, which are sold separately on microchipDIRECT as part numbers AC328904 and AC320005-4, respectively.

The program takes up to approximately 5% (398 KB) of the ATSAME70Q21B microcontroller's program space. The 16-bit

configuration uses 88% (338 KB) of the RAM, including a 32 KB heap.

The following figure illustrates the application architecture, for this configuration:



#### SAM V71 Xplained Ultra Project:

This project runs on the SAM V71 Xplained Ultra Board, which contains a ATSAMV71Q21B microcontroller with 2 MB of Flash memory and 384 KB of RAM running at 300 MHz using the following features:

- One push button
- Two LEDs (only one used)
- WM8904 codec (on board)

The program takes up to approximately 1% (13 KB) of the ATSAME70Q21B microcontroller's program space. The 16-bit configuration uses 74% (284 KB) of the RAM. No heap is used.

The architecture is the same as for the first bare-metal SAM E70 Ultra board configuration; however only it uses the SSC peripheral instead of the I2SC. The WM8904 is configured in master mode and generates the I2SC (LRCLK and BCLK) clocks, and the I2SC peripheral is configured as a slave.

Except for the user interface, the same application code is used without change between the various projects.

The SAM E54/E70/SAM V71 microcontroller (MCU) runs the application code, and communicates with the AK4954 or WM8904 codec via an I<sup>2</sup>C interface. The audio interface between the microcontroller and the WM8904 codec use the I<sup>2</sup>S interface. Audio is configured as 16-bit, 48,000 or 16,000 samples/second, I<sup>2</sup>S format. (16-bit, 48 kHz is the standard rate used for DVD audio. 16 kHz still provides excellent voice quality audio. Another alternative that could be used is 44,100 samples/second. This is the same sample rate used for CD's).

The Master Clock (MCLK) signal used by the codec is generated by the Generic Clock section of the E54, or the Peripheral Clock

section of the SAM E70/V71, and is either 12 MHz (when the codec is configured as a master), or close to 12,288,000 (when the codec is configured as a slave, this frequency being 256 times the sample rate).

In all but one project, the button and LEDs are interfaced using GPIO pins. In the other project, a 480x272 LCD screen is used as the user interface.

As with any MPLAB Harmony application, the `SYS_Initialize` function, which is located in the `initialization.c` source file, makes calls to initialize various subsystems as needed, such as the clock, ports, board support package (BSP), screen (if applicable), WM8904 codec, I<sup>2</sup>S, I<sup>2</sup>C, DMA, timers, and interrupts.

The codec driver and the application state machines are all updated through calls located in the `SYS_Tasks` function in the `tasks.c` file.

When the application's state machine (`APP_Tasks`), contained in `app.c`, is given control it first gets a handle to a timer driver instance and sets up a periodic (alarm) callback. In the next state it gets a handle to the codec driver by calling the `DRV_CODEC_Open` function with a mode of `DRV_IO_INTENT_WRITE` and sets up the volume. The application state machine then registers an event handler `APP_CODEC_BufferEventHandler` as a callback with the codec driver (which in turn is called by the DMA driver).

For the non-graphical version of the app, a total of `MAX_BUFFERS` (#defined as 150) buffers are allocated, each able to hold 10 ms of audio (480 samples at 48,000 samples/second), which is enough for a 1.5 second delay.). For the graphical version, which has less memory available available due to the frame buffer, `MAX_BUFFERS` is set at 101, each able to hold 10 ms of audio based on 160 samples at 16,000 samples/second, therefore enough for one second of delay.

Two indicies, `appData.rxBufferIdx` and `appData.txBufferIdx` are used to track the current buffers for both input and output. Initially all buffers are zeroed out. A call to `DRV_CODEC_BufferAddWriteRead` is made, which writes out the data from the buffer pointed to by `appData.txBufferIdx` (initially zero), while at the same time data is read from the codec into the buffer pointed to by `appData.rxBufferIdx`.

On each callback from the DMA, the buffer pointers are advanced, wrapping around at the ends. After the prescribed delay, the audio from the first buffer filled in will be output.

In the non-graphical version, if the button is held down for more than one second, the mode changes, and there is no delay while the volume is being adjusted. Instead of a circular array of buffers, the first two buffers are just toggled back and forth in a ping-pong fashion. In the graphical version, this mode change is handled through the Enable Delay button on the GUI.

## Demonstration Features

- Uses the Codec Driver Library to input audio samples from the WM8904, and later write them back out to the WM8904
- At a lower level, uses the I<sup>2</sup>S Driver Library between the codec library and the chosen peripheral (SSC or I<sup>2</sup>SC) to send the audio to the codec
- Using either an array of circular buffers to create an audio delay, or two buffers in ping-pong fashion for no delay, both using DMA
- Use of two timers: one as a periodic 1 ms timer for the application for button debouncing, and a second used by the Codec Driver (see Timer Driver Library)
- For the version using the display, use of the touch screen as a UI

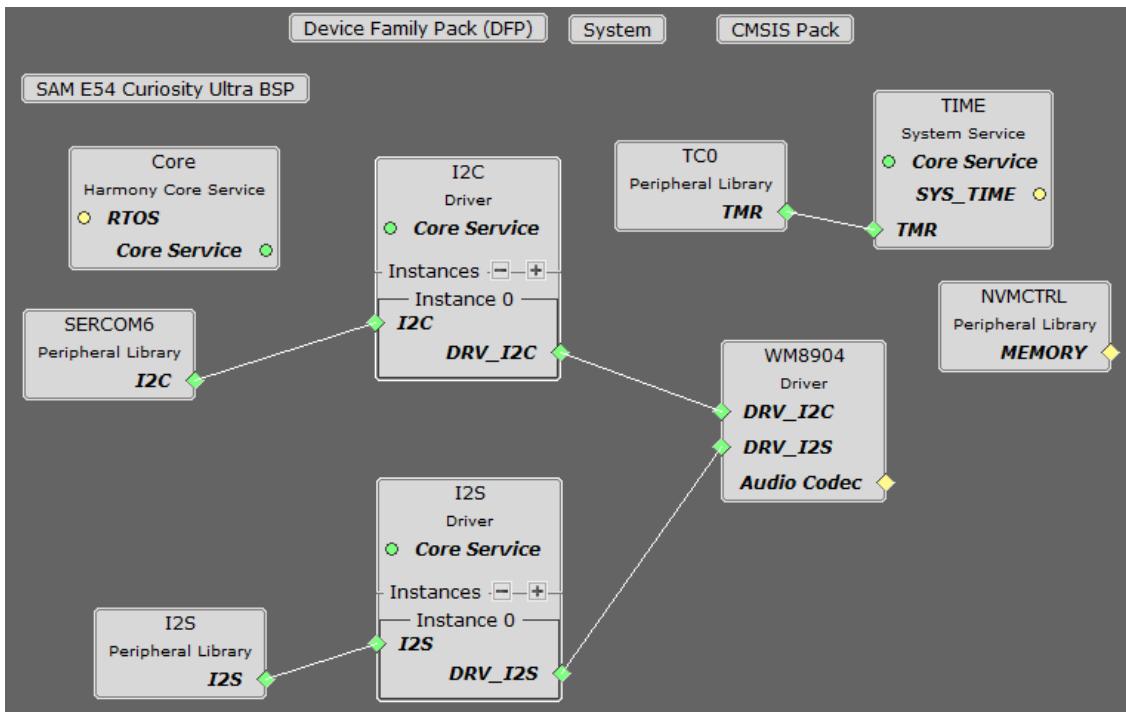
## Tools Setup Differences

For projects using the E54, the I<sup>2</sup>S interface and the WM8904 as a Master (the WM8904 codec generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP. Select the appropriate processor (ATSAME54P20A). Click Finish.

In the MHC, under Available Components select the BSP SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions. Click on the WM8904 Codec component (*not* the WM8904 Driver). In the Configuration Options, under WM8904 Interface, select I<sup>2</sup>SC instead of SSC. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes:

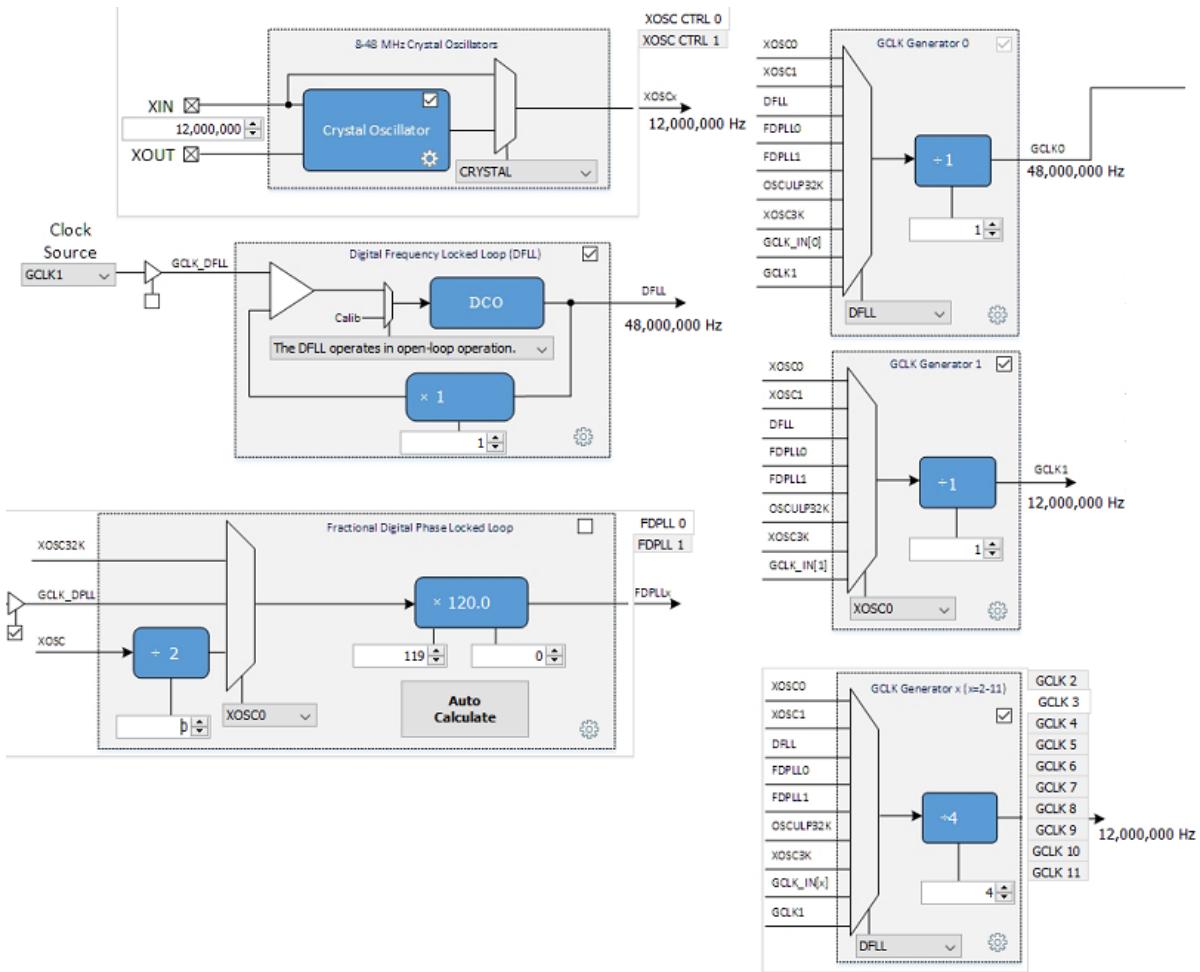


Click on the WM8904 Driver. In the Configurations Options, under Audio Data Format, change it to 32-bit I2S. Set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

In the Clock Diagram:

- Set enable the Crystal Oscillator, change its frequency to 12,000,000 Hz, and select CRYSTAL.
- Uncheck the Fractional Digital Phase Locked Loop enable (FDPLL 0).
- In the CLK Generator 0 box, change the input to DFLL for an output of 48 MHz.
- In the CLK Generator 1 box, change the input to XOSC0 with a divider of 1 for an output of 12 MHz.
- In the GCLK Generator, uncheck the selection for GCLK 2, and then select the GCLK 3 tab. Choose the DFLL as the input, with a divide by 4 for an output of 12 MHz.

You should end up with a clock diagram like this:

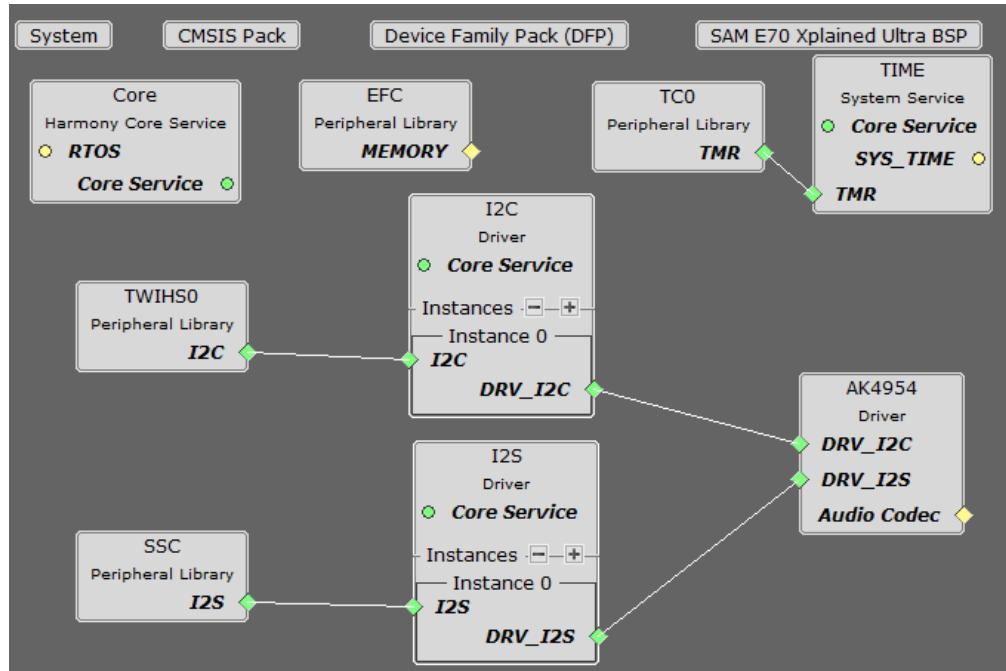


For projects using the E70, the SSC interface and the AK4954 as a Slave (the SAM E70 generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP. Select the appropriate processor (ATSAME70Q21B). Click Finish.

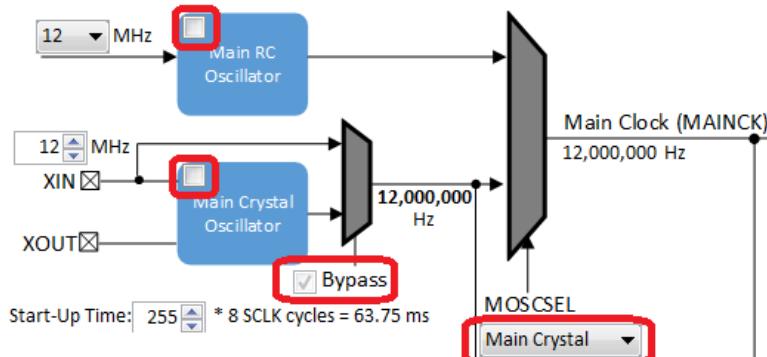
In the MHC, under Available Components select the BSP SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on AK4954 Codec. Answer Yes to all questions. Click on the AK4954 Codec component (*not* the AK4954 Driver). In the Configuration Options, under AK4954 Interface, select I2SC instead of SSC. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes:

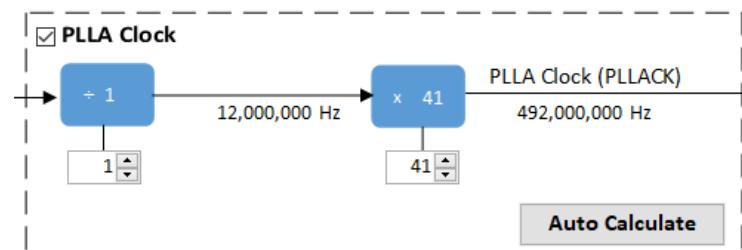


Click on the AK4954 Driver. In the Configurations Options, under Usage Mode, change Master to Slave. Set the desired Sample Rate if different from the default (48,000) under Sampling Rate.

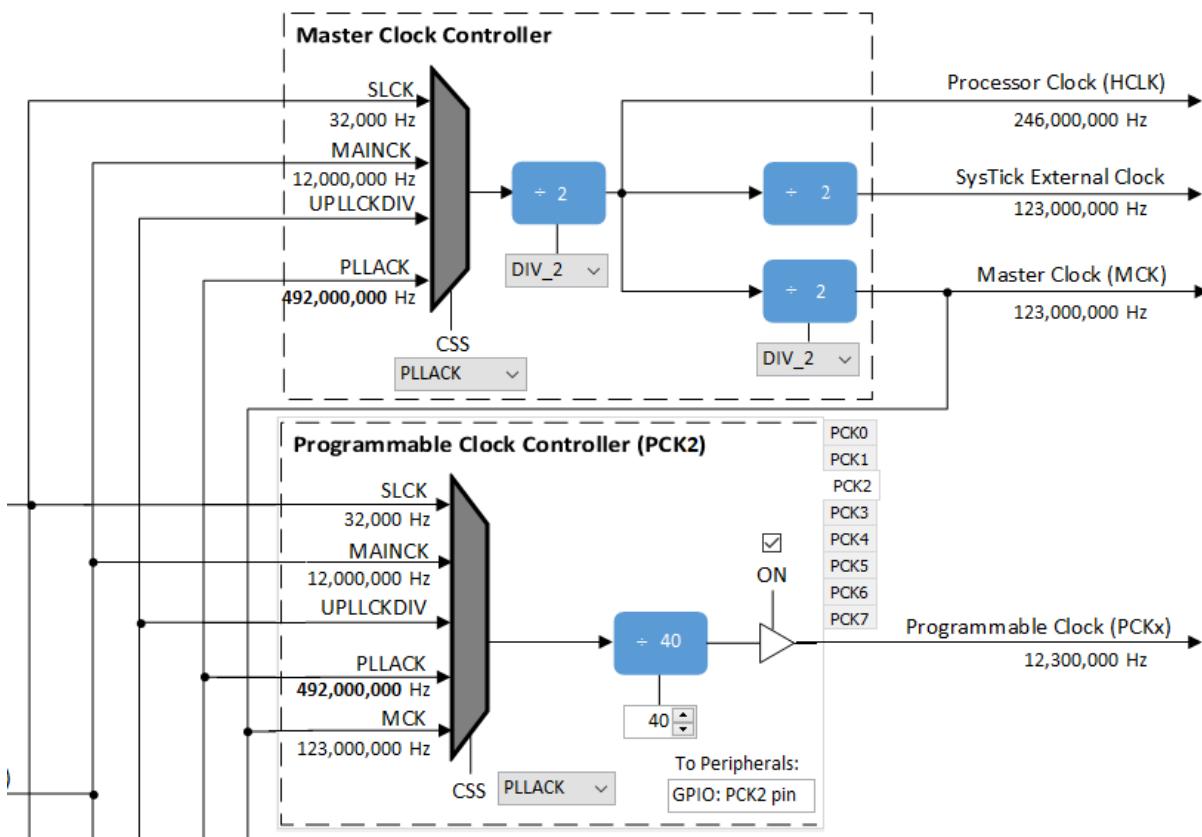
In the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



Still in the Clock Diagram, enable the PLLA Clock. Leave the divider at 1 (12 MHz) and change the multiplier to 41 for an output of 492 MHz.



In the Master Clock Controller, select the source (CSS) as PLLACK (492 MHz), all three dividers as divide by 2 to generate a Processor Clock of 246 MHz and a Master Clock of 123 MHz. In the Programmable Clock Controller section, select the PCK2 tab, select the source (CSS) as PLLACK (492 MHz), the divider of 40 for a PCK2 output of 12,300,000 Hz



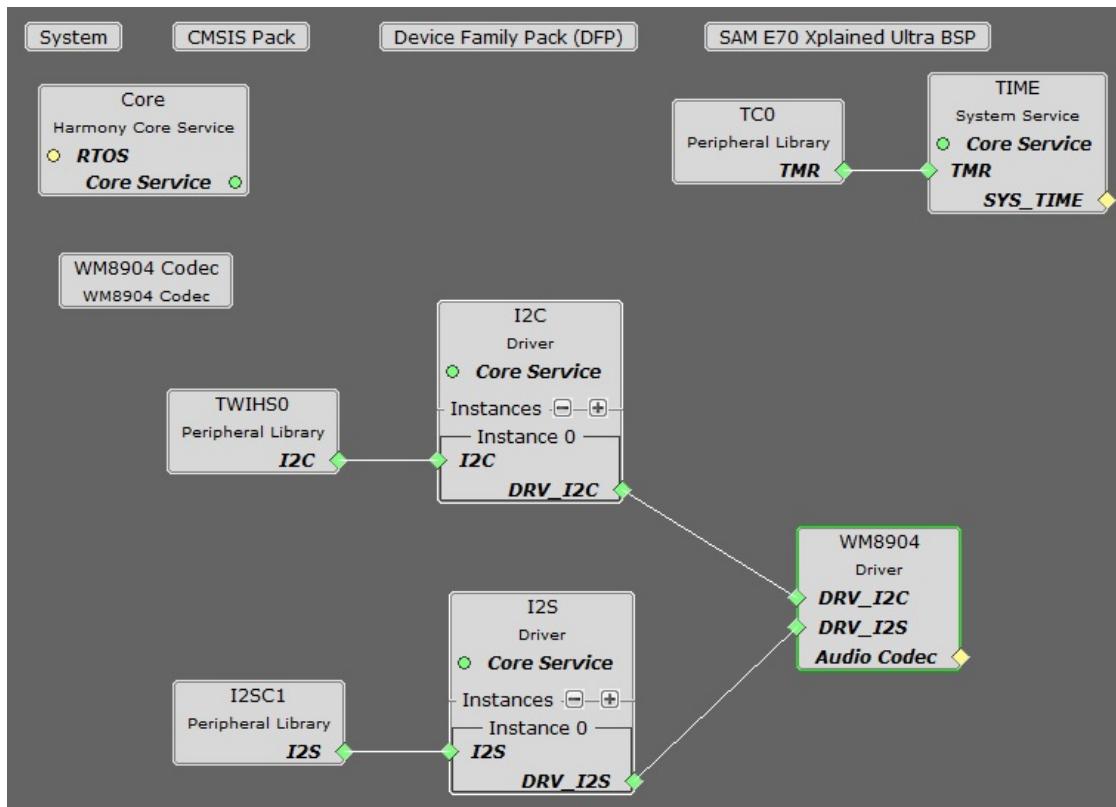
Then check the SSC checkbox in the **Peripheral Clock Controller** section..

For projects using the I<sup>2</sup>S interface and the WM8904 as a Slave (the SAM E70 generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP. Select the appropriate processor (ATSAME70Q21B). (The WM8904 on the SAM V71 Xplained Ultra cannot be used with I<sup>2</sup>S.) Click Finish.

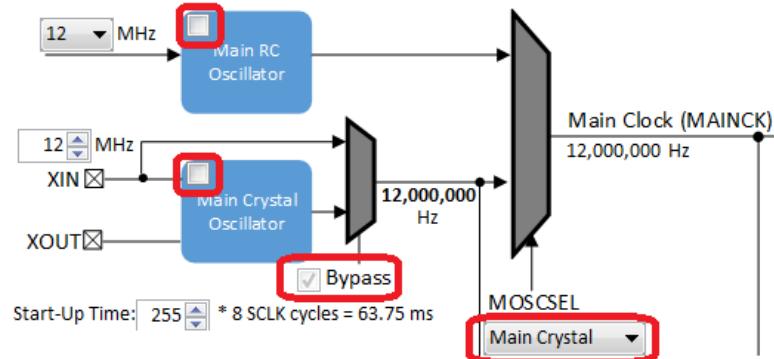
In the MHC, under Available Components select the BSP SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions. Click on the WM8904 Codec component (*not* the WM8904 Driver). In the Configuration Options, under WM8904 Interface, select I<sup>2</sup>S instead of SSC. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes, assuming a non-FreeRTOS project:



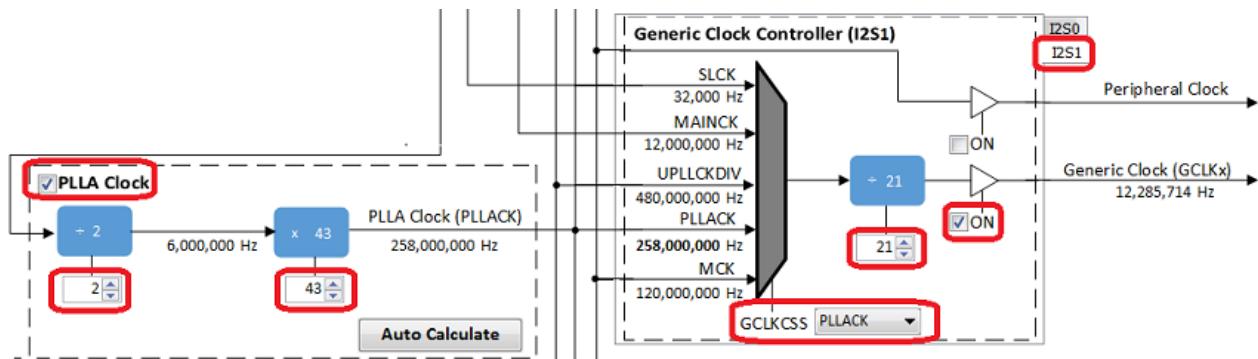
Click on the WM8904 Driver. In the Configurations Options, under Usage Mode, change Master to Slave. Set the desired Sample Rate if different from the default (48,000) under Sampling Rate. Select Enable Microphone Input, and Enable Microphone Bias for elecret microphones if appropriate.

If using the SAM E70 Xplained Ultra board, in the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



In the Clock Diagram, in the PCK2 tab of the **Programmable Clock Controller** section, check the **On** checkbox, and set CSS to MAINCLK (12 MHz).

The following tables show suggested settings for various sample rates in the Clock Diagram when using the I2SC Peripheral in Master mode. Make sure **PLL Clock** checkbox is checked, and fill in the values for the PLLA Multiplier and Divider boxes. Select the I2S1 tab under **Generic Clock Controller**, set GCLKCSS to PLLACK, fill in the Divider value as shown, and check the checkbox next to it.



The values in the first table give the lowest error rate, but have varying PLLACK values so it is best to use the UPPCLKDIV selection for CSS under **Master Clock Controller**, for a Processor Clock of 240 MHz.

Desired Sample Rate	PLLA Multiplier	PLLA Divider	PLLACK	I2SC Generic Clock Divider	Calculated Sample Rate	Error
8000	2	43	258 MHz	126	7998	-0.025%
16000	2	43	258 MHz	63	15997	-0.0187%
44100	1	16	192 MHz	17	41117	0.0385%
48000	2	43	258 MHz	21	47991	-0.0187%
96000	3	43	172 MHz	7	95982	-0.0187%

The values in the second table have somewhat higher error rates, but use a PLLACK value of 294 MHz which is suitable to be used as a Processor Clock (using the PLLACK selection for CSS) which is closer to the maximum of 300 MHz.

Desired Sample Rate	PLLA Multiplier	PLLA Divider	PLLACK	I2SC Generic Clock Divider	Calculated Sample Rate	Error
8000	2	49	294 MHz	144	7975	-0.3125%
16000	2	49	294 MHz	72	15950	-0.3125%
44100	2	49	294 MHz	26	41170	0.1587%
48000	2	49	294 MHz	24	47851	-0.3104%
96000	3	49	294 MHz	12	95703	-0.3094%

It is also possible to change the audio format from 16 to 32-bits. This changes need to be done in the MHC in both the WM8904 Driver and SSC Peripheral. In the current application code (app.h), a #define is also set to the current width.

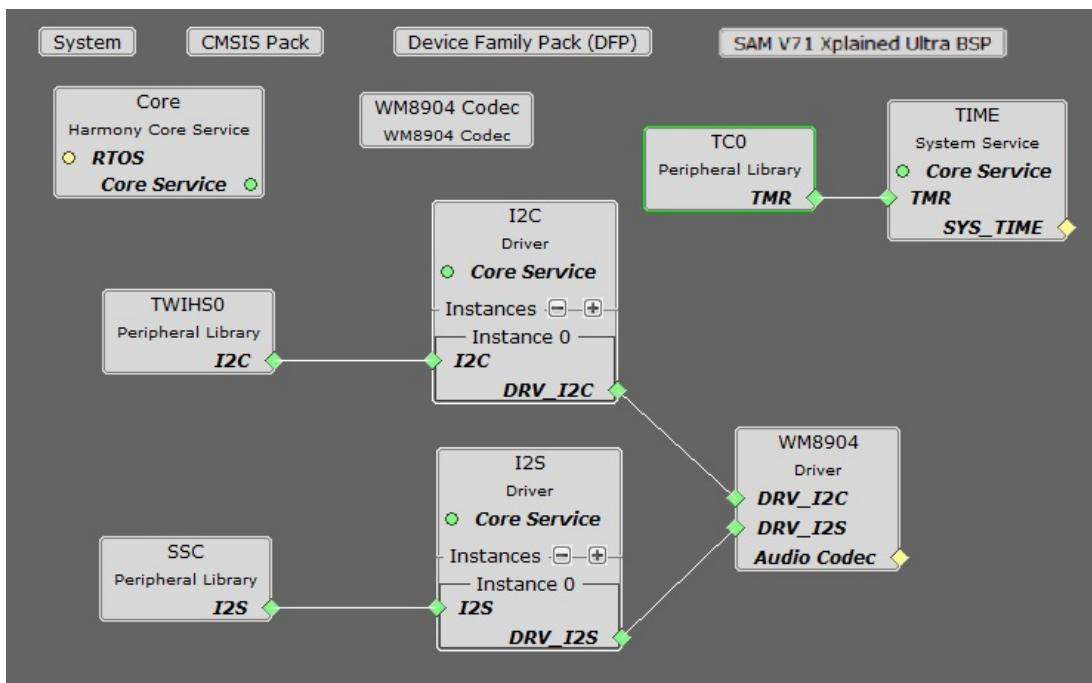
If using FreeRTOS, in the code you will need to move the call to `DRV_WM8904_Tasks(sysObj.drvwm8904Codec0);` from the `SYS_Tasks` function in `src/config/<config_name>/tasks.c` to inside the `while(1)` loop of `_APP_Tasks` (just before the call to `APP_Tasks`).

For projects using the SSC interface and the WM8904 as a Master (the WM8904 codec generates the I<sup>2</sup>S clocks):

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name the same based on the BSP used. Select the appropriate processor (e.g. ATSAMV71Q21B) depending on your board. Click Finish.

In the MHC, under Available Components select the appropriate BSP (e.g. SAM V71 Xplained Ultra). Under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions except for the one regarding FreeRTOS; answer Yes or No to that one depending on whether you will be using FreeRTOS or not.

You should end up with a project graph that looks like this, after rearranging the boxes, assuming a non-FreeRTOS project:



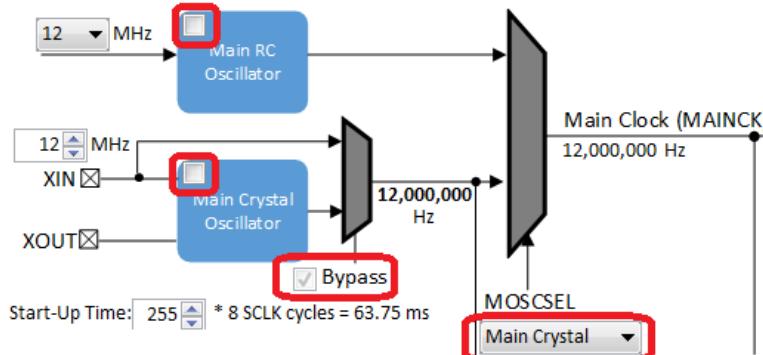
If building an application that is going to use the 480x272 display, then do the following instead. In the MHC, under Available Components select the BSP (SAM E70 Xplained Ultra). Under *Graphics>Templates*, double-click on Aria Graphics w/ PDA TM4301B Display. Answer Yes to all questions except for the one regarding FreeRTOS; answer No to that one.

Then under *Audio>Templates*, double-click on WM8904 Codec. Answer Yes to all questions.

You should end up with a project graph that looks like this, after rearranging the boxes:

In either case, click on the WM8904 Driver. In the Configurations Options, set the desired Sample Rate if different from the default (48,000) under Sampling Rate. Select Enable Microphone Input, and Enable Microphone Bias for elecret microphones if appropriate.

If using the SAM E70 Xplained Ultra board, in the Clock Diagram, in the Clock Diagram, set MOSCEL to Main Crystal, check the Bypass checkbox, and uncheck the RC Crystal Oscillator and Main Crystal Oscillator boxes, to make use of the 12 MHz external oscillator:



If using the ATSAMV71Q21B, in the Clock Diagram set MOSCEL to Main Crystal, uncheck the Bypass checkbox and RC Crystal Oscillator checkbox, and check the Main Crystal Oscillator box.

Also in the Clock Diagram, in the PCK2 tab of the **Programmable Clock Controller** section, check the On checkbox, and set CSS to MAINCLK (12 MHz). Then check the SSC checkbox in the **Peripheral Clock Controller** section.

It is also possible to change the audio format from 16 to 32-bits, and from I2S to Left Justified (SSC only). These changes need to be done in the MHC in both the WM8904, and SSC/I2SC Peripherals. In the current application code (app.h), a #define is also set to the current width.

If using FreeRTOS, in the code you will need to move the call to `DRV_WM8904_Tasks(sysObj.drvwm8904Codec0);` from the `SYS_Tasks` function in `src/config/<config_name>/tasks.c` to inside the while(1) loop of `_APP_Tasks` (just before the call to `APP_Tasks`).

## Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

### Description

The parent folder for these files is `audio/apps/audio_microphone_loopback`. To build this project, you must open the `audio/apps/audio_microphone_loopback/firmware/*.X` project file in MPLAB X IDE that corresponds to your hardware configuration.

### MPLAB X IDE Project Configurations

The following table lists and describes supported configurations.

Project Name	BSP Used	Description
<code>audio_tone_sam_e54_cult_wm8904_ssc</code>	<code>sam_e54_cult</code>	This demonstration runs on the ATSAME54P20A processor on the SAM E54 Curiosity Ultra board and the WM8904 Audio Codec Daughter Board. The configuration is for a 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave.
<code>audio_tone_sam_e54_cult_wm8904_ssc_freertos</code>	<code>sam_e54_cult</code>	This demonstration runs on the ATSAME54P20A processor on the SAM E54 Curiosity Ultra board and the WM8904 Audio Codec Daughter Board. The configuration is for a 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave. This demonstration also uses FreeRTOS.
<code>audio_tone_sam_e70_xult_ak4954_ssc</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the AK4954 Audio Codec Daughter Board. The configuration is for a 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB.. The AK4954 codec is configured as the slave, and the SSC peripheral as the master.
<code>mic_loopback_sam_e70_xult_wm8904_i2sc</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board. The configuration is for a 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the I2SC PLIB. The WM8904 codec is configured as the slave, and the I2SC peripheral as the master.
<code>mic_loopback_sam_e70_xult_wm8904_i2sc_freertos</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board. The configuration is for a 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the I2SC PLIB. The WM8904 codec is configured as the slave, and the I2SC peripheral as the master. This demonstration also uses FreeRTOS.
<code>mic_loopback_sam_e70_xult_wm8904_ssc_wqvga</code>	<code>sam_e70_xult</code>	This demonstration runs on the ATSAME70Q21B processor on the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, plus a PDA TM4301B 480x272 (WQVGA) display. The configuration is for a 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave. This demonstration also uses FreeRTOS.

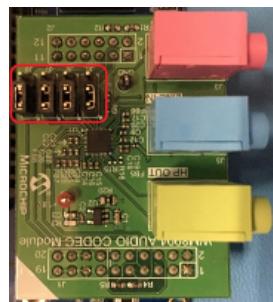
mic_loopback_sam_v71_xult	sam_v71_xult	This demonstration runs on the ATSAMV71Q21B processor on the SAMV71 Xplained Ultra board along with the on-board WM8904 codec. The configuration is for a 16-bit data width, 48000 Hz sampling frequency, and I <sup>2</sup> S audio protocol using the SSC PLIB. The WM8904 codec is configured as the master, and the SSC peripheral as the slave.
---------------------------	--------------	--

## Configuring the Hardware

This section describes how to configure the supported hardware. SAM V71 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, using the SSC PLIB. No configuration is necessary.

### Description

Using the SAM E54 Curiosity Ultra board and the WM8904 Audio Codec Daughter Board, and the SSC PLIB. All jumpers on the WM8904 should be toward the **front**:



In addition, make sure the J401 jumper (CLK SELECT) is set for the PA17 pin:

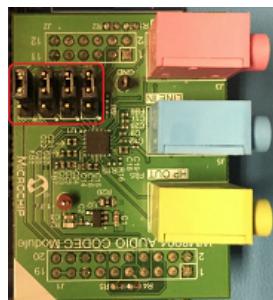


→ **Note:** The SAM E54 Curiosity Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

Using the SAM E70 Xplained Ultra board and the AK4954 Audio Codec Daughter Board, and the SSC PLIB. No special configuration needed.

→ **Note:** The SAM E70 Xplained Ultra board does not include the AK4954 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC324954.

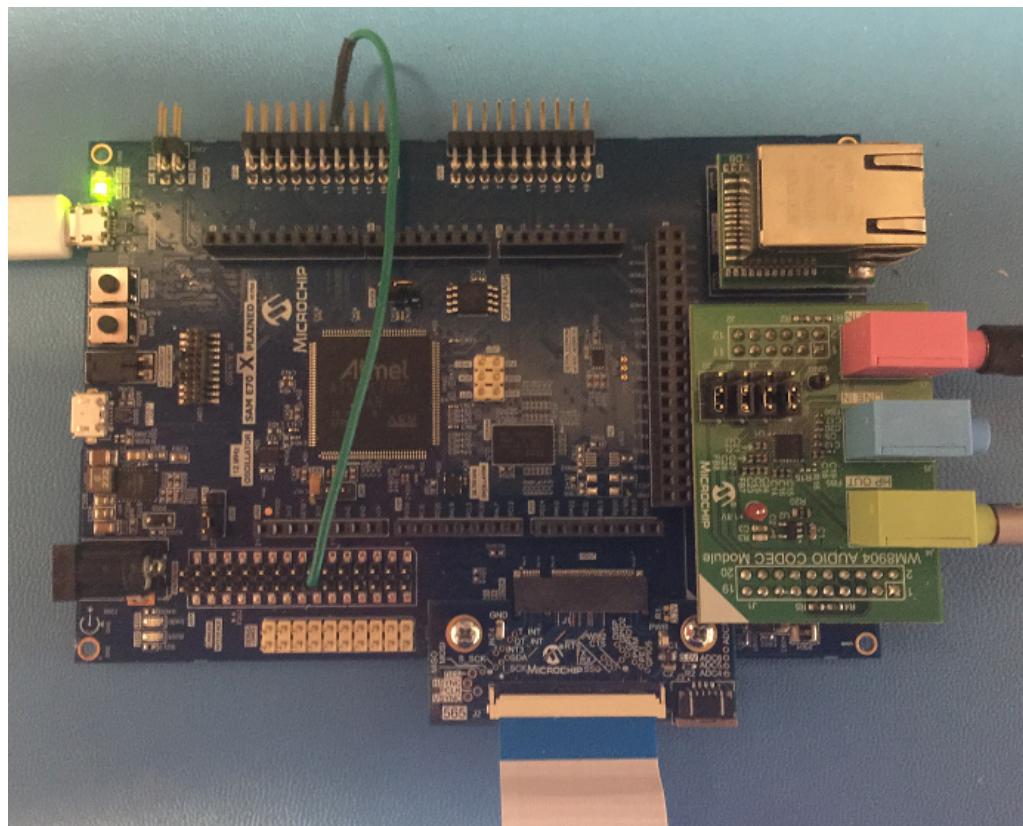
Using the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, and the I<sup>2</sup>SC PLIB. All jumpers on the WM8904 should be toward the **back**:



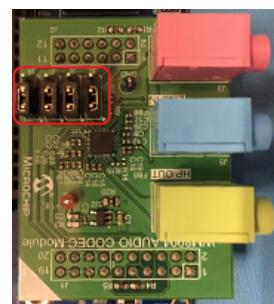
→ **Note:** The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

Using the SAM E70 Xplained Ultra board and the AK4954 Audio Codec Daughter Board, and the SSC PLIB and the 480x272 display.

- Attach the flat cable of the PDA TM4301B 480x272 (WQVGA) display to the 565 daughterboard connected to the SAM E70 Xplained Ultra board GFX CONNECTOR.
- Add a jumper from connector EXT1 pin 13 to J601 (CAMERA INTERFACE) pin 14 as shown:



The WM8904 Audio Codec Daughter Board will be using the SSC PLIB; all jumpers on the WM8904 should be toward the **front**:



- **Note:** The SAM E70 Xplained Ultra board does not include the PDA TM4301B 480x272 (WQVGA) display, which is sold separately on microchipDIRECT as part number AC320005-4, or the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

Using the SAM V71 Xplained Ultra board with on-board WM8904, with the SSC PLIB. No special configuration needed.

### Running the Demonstration

This section demonstrates how to run the demonstration.

### Description

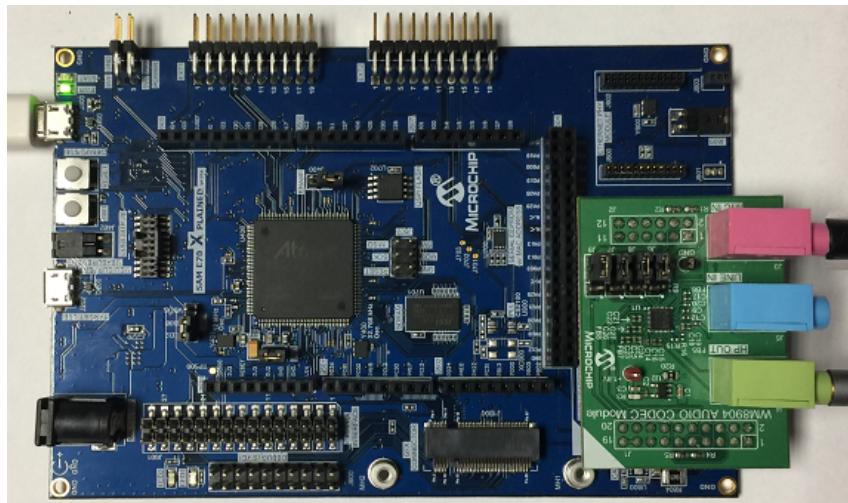
- Important!** Prior to using this demonstration, it is recommended to review the MPLAB Harmony 3 Release Notes for any known issues.

### Projects using a Pushbutton LED User interface:

Compile the program using MPLAB X, and program the target device using the EDBG interface. While compiling, select the appropriate MPLAB X IDE project. Refer to [Building the Application](#) for details.

Four different delays can be generated. **Table 1** provides a summary of the button actions that can be used to control the volume and delay amount.

1. Connect headphones to the HP OUT jack of the AK4954 or WM8904 Audio Codec Daughter Board (see [Figure 1](#)), or the HEADPHONE jack of the SAM V71 Xplained Ultra board.
2. Connect a microphone to the MIC IN jack of the WM8904 Audio Codec Daughter Board (see [Figure 1](#)), or the MICROPHONE jack of the SAM V71 Xplained Ultra board.
3. Initially the program will be in delay-setting mode (LED1 on) at a medium volume setting. Pressing SW1 with LED1 on will cycle through four delay settings.
4. Pressing SW1 longer than one second will change to volume-setting mode (LED1 off). Pressing SW1 with LED1 off will cycle through four volume settings (including mute).
5. Pressing SW1 longer than one second again will switch back to delay-setting mode again (LED1 on).



**Figure 1:** WM8904 Audio Codec Daughter Board on SAM E70 Xplained Ultra board

## Control Descriptions

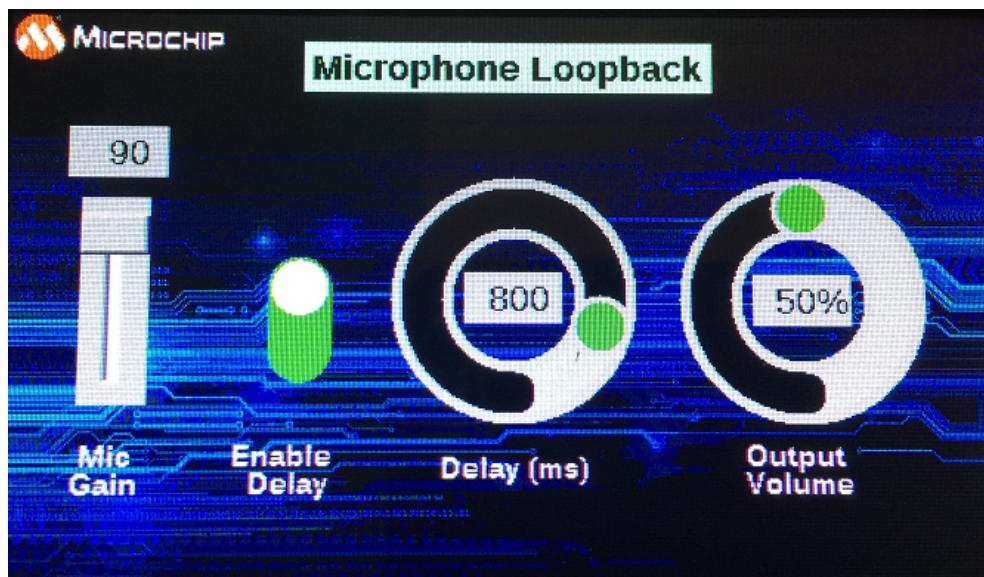
**Table 1: Button Controls for SAM E70 Xplained Ultra board and SAM V71 Xplained Ultra board**

Control	Description
SW1 short press	If LED1 is off, SW1 cycles through four volume levels (one muted). If LED1 is on, SW1 cycles through four delays: $\frac{1}{4}$ second, $\frac{1}{2}$ second, 1 second and $1\frac{1}{2}$ seconds.
SW1 long press (> 1 second)	Alternates between modes (LED1 on or off).

## Project using a Graphical User Interface:

Compile the program using MPLAB X, and program the target device using the EDBG interface. While compiling, select the appropriate MPLAB X IDE project. Refer to [Building the Application](#) for details.

1. Connect headphones to the HP OUT jack of the WM8904 Audio Codec Daughter Board (see [Figure 1](#)).
2. Connect a microphone to the MIC IN jack of the WM8904 Audio Codec Daughter Board (see [Figure 1](#)).
3. Initially the program will be in delay-setting mode, with a 800 ms delay and a medium volume setting.
4. The Delay can be adjusted from 10 ms to 1000 ms (1 second) using the center circular control.
5. The Output Volume can be adjusted from 0% to 100% using the circular control on the right.
6. The Microphone Gain can be adjusted from 0% to 100% using the slider on the left.
7. Adjusting the microphone gain or output volume causes the delay to be temporarily disabled. Re-enable the previous value using the Enable Delay switch.
8. The Enable Delay switch can also be manually toggled at any time to disable the delay and provide immediate microphone loopback to the headphones.



## usb\_speaker

This topic provides instructions and information about the MPLAB Harmony 3 USB Speaker Basic demonstration application, which is included in the MPLAB Harmony Library distribution.

### Description

The USB Device driver in Full Speed mode will interface to a USB Host (such as a personal computer) via the USB Device Stack using the V1.0 Audio Function Driver. The embedded system will enumerate with a USB audio device endpoint and enable the host system to input audio from the USB port using a standard USB Full-Speed implementation. The embedded system will stream USB playback audio to the Codec. The Codec Driver sets up the audio interface, timing, DMA channels and buffer queue to enable a continuous audio stream. The digital audio is transmitted to the codec through an I2S data module for playback through a headphone jack.

### Architecture

The application runs on the SAM E70 Xplained Ultra Board, which contains a at 300 MHz using the following features:

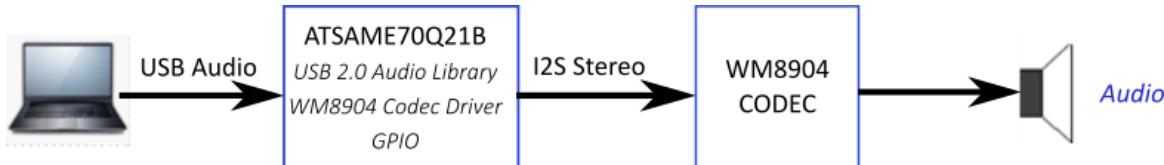
- One push button
- Two LEDs (amber and green). Only the amber LED can be used for a USB Device requiring VBUS sense.
- WM8904 Codec Daughter Board mounted on a X32 socket

The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

The `usb_speaker_basic` application uses the MPLAB Harmony Configurator to setup the USB Audio Device, codec, and other items in order to play back the USB audio through the WM8904 Codec Module.

A USB Host system is connected to the micro-mini USB device connector. The application detects the cable connection, which can also supply device power; recognizes the type of connection (Full Speed); enumerates its functions with the host, isochronous audio streaming playback through device. Audio stream data is buffered in 1 ms frames for playback using the WM8904 Codec daughter board. Audio is heard through the Headphone jack (HP OUT).

The following figure shows the basic architecture for the demonstration.



### Demonstration Features

- Playback using an WM8904 codec daughterboard on the SAM E70 Xplained Ultra (E70 XULT) board.

- USB connection to a host system using the USB Library Device Stack for a USB Speaker device using E70 XULT
- E70XULT Button processing for volume/mute control
- USB Attach/Detach and mute status using an LED.

The following API calls are made to the USB Library:

- USB\_DEVICE\_Open - Configures the USB Device
- USB\_DEVICE\_EventHandlerSet -- Registers APP\_USBDeviceEventHandler.
- USB\_DEVICE\_AUDIO\_Read -- Reads a 48Kh/16bit stereo audio buffer.

The following callbacks are registered to the USB Device Library:

- APP\_USBDeviceEventHandler - Handles USB interface events
- APP\_USBDeviceAudioEventHandler - Handles Read/Write buffer complete events.

Note that all the calls to the USB Library Device Stack library use the form USB\_DEVICE\_xxx. This makes the code more generic, such that another library could be substituted without having to make changes to the application code except for the location of the library public header files.

The codec driver API calls used are:

- DRV\_CODEC\_Open – Open the driver for write Only.
- DRV\_CODEC\_BufferEventHandlerSet – Register APP\_CODECBufferEventHandler
- DRV\_CODEC\_SamplingRateSet – Change sampling rate
- DRV\_CODEC\_BufferAddWrite – add an input buffer to the receive buffer queue
- DRV\_CODEC\_Mute<On,Off> - Codec mute control

The following callbacks are registered to the Codec driver:

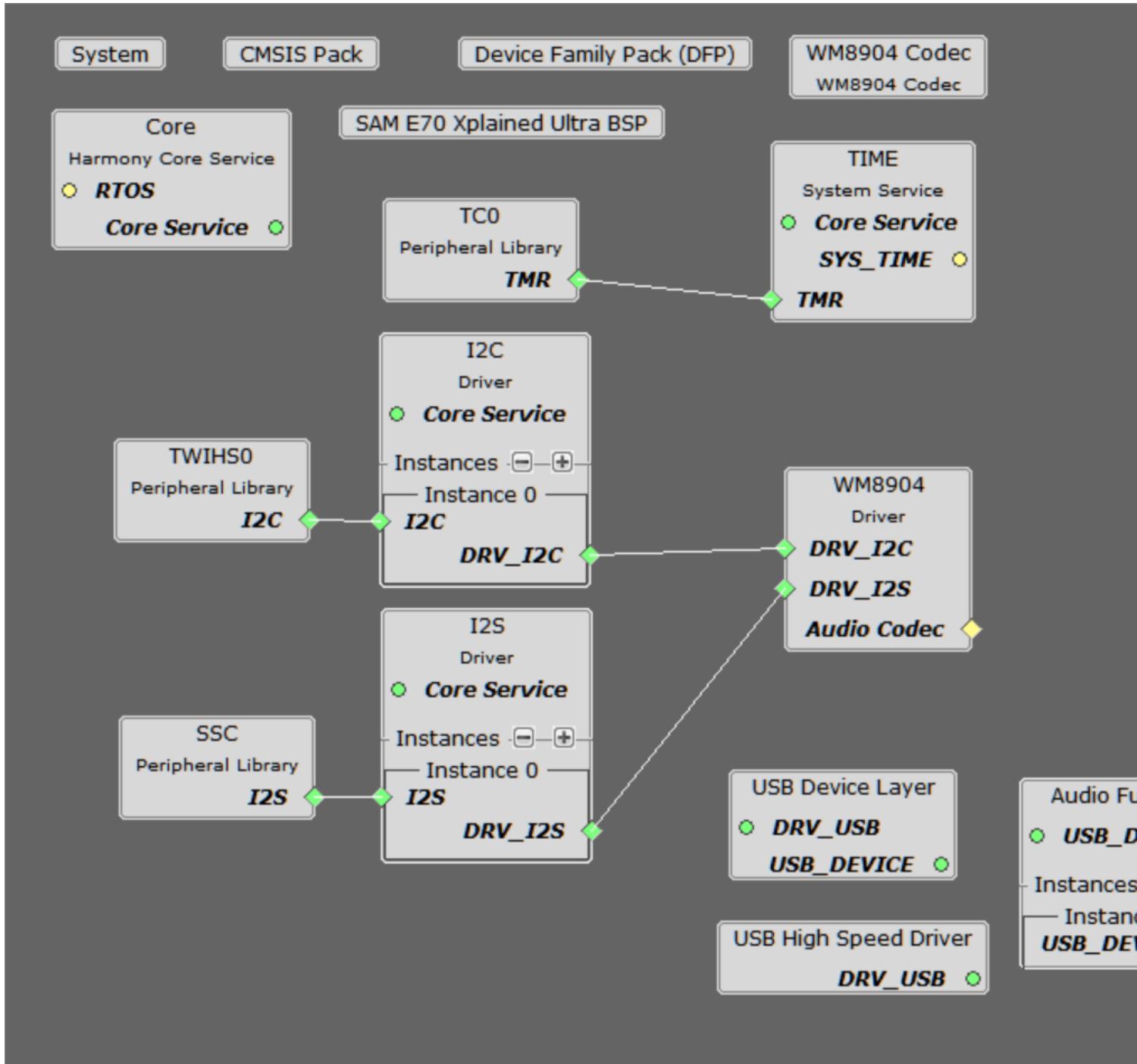
- APP\_CODECBufferEventHandler - Handles audio buffer complete events

Note that all the calls to the WM8904 codec driver use the form DRV\_CODEC\_xxx rather than DRV\_WMW8904\_xxx. This is to make the code more generic, such that another codec could be substituted for another without having to make changes to the application code except for the location of the driver's public header file.

## Tools Setup Differences

### Harmony Configuration

The MHC Project Graph for usb\_speaker\_basic is shown below.



USB Speaker Basic MHC Project Graph

Each block provides configuration parameters to generate the application framework code. This includes all the needed drivers, middleware, libraries. The generated framework code is placed under the firmware/src/config directory for this usb\_speaker application (usb\_speaker\_basic\_sam\_e70\_xult\_wm8904\_usb). The usb\_speaker\_basic application code is located in the firmware/src directory app.c and app.h files, which utilize the framework drivers, middleware and library APIs located in definitions.h (as generated by the configurator).

## Harmony Code Generation

All Harmony applications use the function SYS\_Initialize function located in the source file also located in initialization.c. This is executed from main to initialize various subsystems such as the clock, ports, BSP (board support package), codec, usb, timers, and interrupts. The application APP\_Initialize function in app.c is also executed in this routine to setup the application code state machine.

The USB, WM8904 driver, and the application state machines (APP\_Tasks routine) are all updated via calls located in the function

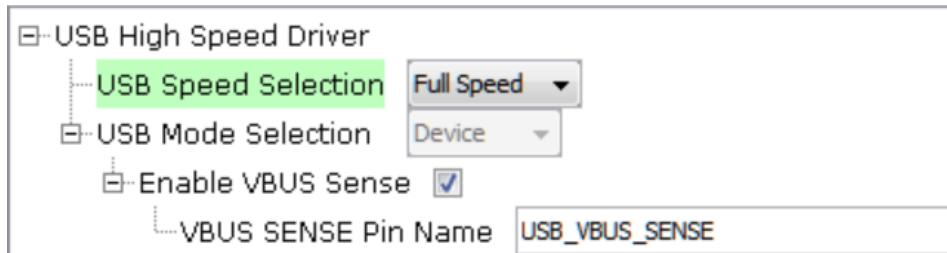
SYS\_Tasks, executed from the main polling loop, located in tasks.c.

The application code is contained in the standard source file app.c. The application utilizes a simple state machine (APP\_Tasks) executed from SYS\_Tasks) with the following functions

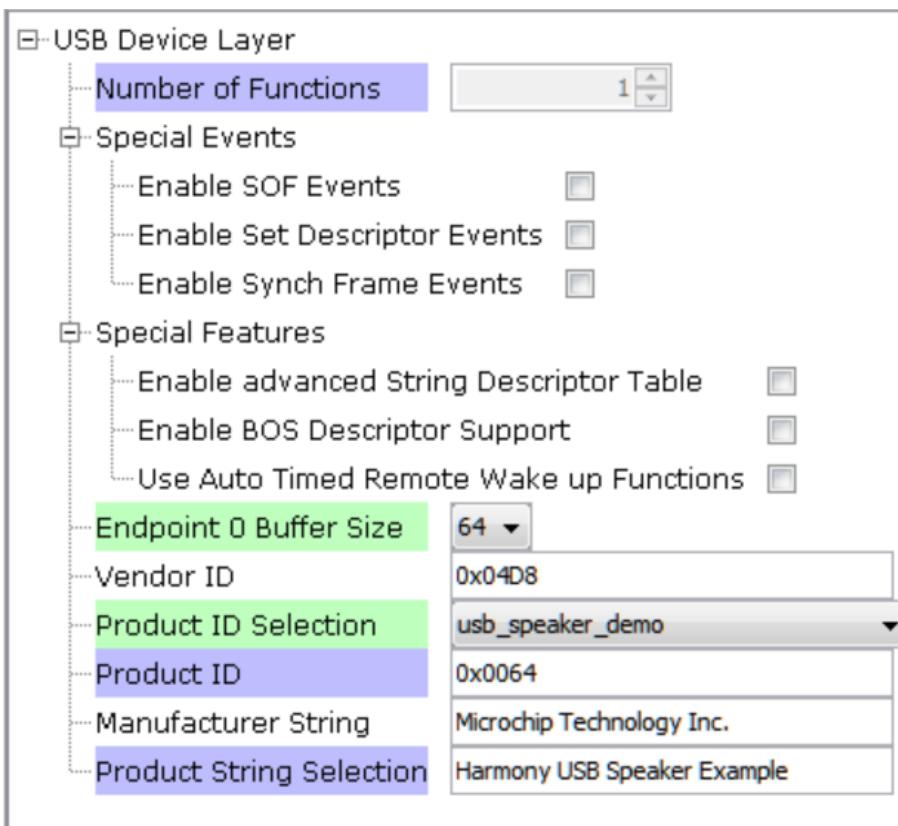
1. Setup the drivers and USB Library interface
2. Respond to USB Host control commands ("Attach", "Detach", "Suspend")
3. Initiate and maintains the bidirectional data audio streaming for the "USB Playback" function.

## USB Configuration

The application uses USB Library as a "Device" stack, which will connect to a "Host". The USB High Speed Driver is selected to by "Full Speed" (not "High Speed"):



The USB Device Layer is configured by selecting the "usb\_speaker\_demo" with an endpoint buffer size of 64 (bytes). The Audio Function Driver is configured for 5 USB endpoints with a single function having 3 interfaces. All of these are defined for a USB Speaker device in the fullSpeedConfigurationDescriptor array variable structure (located in initialization.c under the config folder). This structure defines the connection to the host at 48 KHz with 16 bit stereo channel data. A packet queue of length APP\_QUEUE\_SIZE (set to 32) is used for playback data. The maximum USB packets size is set to 48 \* 2 channels/sample \* 2 bytes/channel= 192 bytes, which gives a 1ms stereo sample packet size at 48Khz (the standard data frame length at this rate), thus the buffer size needs to be of the same size.



The Audio Function Driver is configured with a Audio Read Queue that matches that of the codec driver write queue for this Audio V1.0 USB Speaker interface.

**Audio Function Driver**

- Start Interface Number
- Audio Device Type
- Version
- Use Interface Association Descriptor
- Number of Interfaces
- Number of Audio Streaming Interfaces
- Maximum Number of Interface Alternate Settings
- Audio Read Queue Size
- Audio Write Queue Size
- IN Endpoint Number

### The WM8904 Codec

The WM8904 codec uses a TWIHS (I2C) interface for configuration and control register setting and a SSC (I2S) interface for audio data. The default settings are used as shown below:

**WM8904**

- I2C Driver used
- I2S Driver used
- Usage Mode
- Number of WM8904 Driver Clients
- Sampling Rate
- Volume for the Codec in range 0(Min) to 255(Max)
- Audio Data Format
- Must match Audio Protocol and Data Length field in I2SC/SSC PLIB
- Enable Microphone Input

The SSC uses a Transfer queue size that matches that of the USB Read Queue:

The screenshot shows the MHC configuration interface for the I2S module. The 'I2S' section is expanded, displaying various configuration parameters. The 'Transfer Queue Size' parameter is highlighted with a green background, indicating it is currently selected or being configured. Other visible parameters include 'PLIB Used', 'Number of clients', 'I2S Data Length', 'Must match Data Length field in I2SC/SSC PLIB', 'Use DMA for Transmit and Receive?', 'Use DMA for Transmit?', 'DMA Channel for Transmit', 'Use DMA for Receive?', 'DMA Channel For Receive', and 'Include Linked List DMA Functions?'. Each parameter has associated input fields such as dropdown menus and checkboxes.

## Pin Manager

The buttons, LED, Switch, I2S and I2C interfaces using GPIO pins via the Microchip Harmony Configurator (MHC) Pin Manager, as follows:

NAME	PORT	Rev 4.0 PIN	Notes
SSC_TK	PB01	20	I2S BCLK
SSC_TF	PB00	21	I2S LRCK
PMC_PCK2	PA18	24	I2S MCLK (Master Clock)
SSC_TD	PD26	53	I2S Data
SWITCH	PA11	66	Push Button
LED	PA05	73	
TWIHS0_TWCK0	PA04	77	I2C
TWIHS0_TWD0	PA03	91	I2C
STDBY	PD11	98	
LED2/VBUS DETECT(J204)	PB08	141	J204 (On Rev4.0 and new Rev2.0) set to VBUS DETECT for USB Device

## Clock Manager

All clocks are generated from the 12 MHz Main Clock oscillator. From this clock is derived the following clocks:

Clock	Value	Description
HCLK	300 MHz	Processor Clock
PCK2	12 MHz	Peripheral Clock 2
USB FS	48 MHz	USB Full Speed Clock

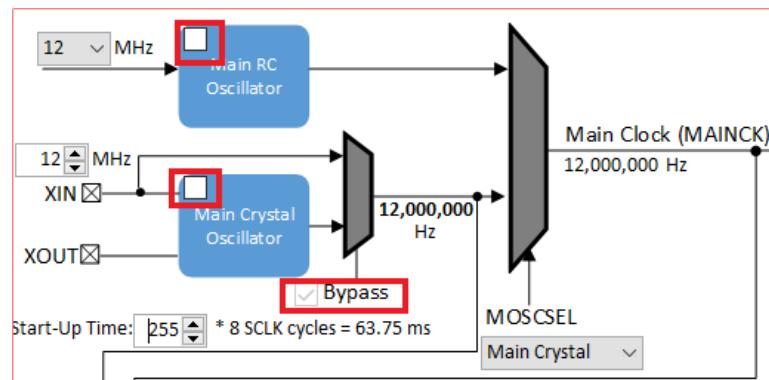
The I2S clocks are setup for 48KHz sampling rate, with stereo 16 bit samples, giving a 32 bit sample frame. The I2S clocks are generated from the WM8904 acting as I2S master using the 12.288 Mhz master clock obtained from Peripheral Clock 2 (PCK2).

The I2S clocks will then be generated, as follows:

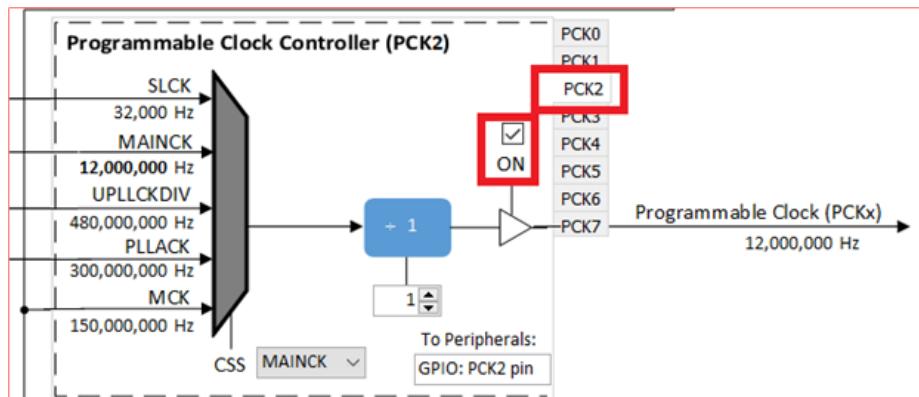
I2S Function	Value	Description
LRCK	48.000000 K	Sample rate clock
BCLK	3072000 Hz	Bit Rate Clock
MCLK	12.288000 MHz	Master Clock

### MPLAB Harmony Configurator: Tools>Clock Configuration

Uncheck the Main RC Oscillator and check the “Bypass” for the Main Crystal Oscillator. When the Bypass is checked, it will cause the Main Crystal Oscillator to become disabled. An external MEMS oscillator input on the XIN pin is used for Main Clock generation.

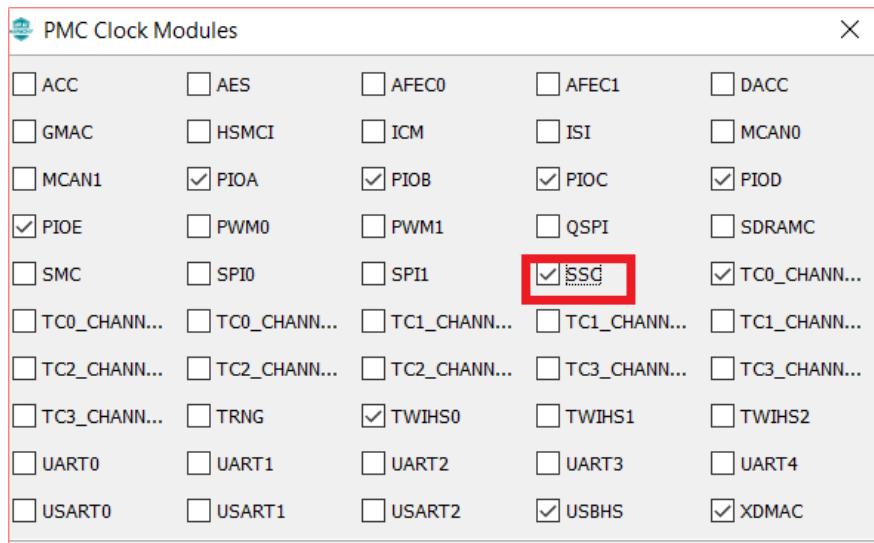


Enable the PCK2 output to enable the WM8904 master clock generation, to enable clocking for the SSC operating as a slave I2S:



Clock Diagram>Peripheral Clock Enable

Enable the peripheral clock to the SSC using the Peripheral Clock Enable of the Peripheral Clock Controller:



## Building the Application

This section identifies the MPLAB X IDE project name and location and lists and describes the available configurations for the demonstration.

## Description

The parent folder for these files is `audio/apps/usb_speaker`. To build this project, you must open the `audio/apps/usb_speaker_basic/firmware/*.x` project file in MPLAB X IDE that corresponds to your hardware configuration.

### MPLAB X IDE Project

This table lists the name and location of the MPLAB X IDE project folder for the demonstration.

### MPLAB X IDE Project Configurations

This table lists and describes the supported configurations of the demonstration, which are located within `./firmware/src/config`.

Project Name	BSP Used	Description
<code>us_basic.sam_e70_xult_wm8904_ssc_usb</code>	<code>sam_e70_xult</code>	This demonstration runs on the SAM E70 Xplained Ultra board with the WM8904 daughter board
<code>us_basic.sam_e70_xult_wm8904_ssc_usb_freertos</code>	<code>sam_e70_xult</code>	This demonstration runs on the SAM E70 Xplained Ultra board with the WM8904 daughter board. It also uses FreeRTOS.

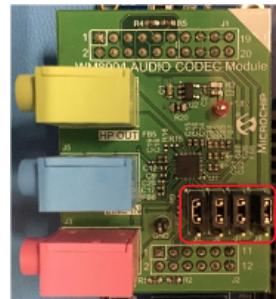
## Configuring the Hardware

This section describes how to configure the supported hardware.

## Description

Using the SAM E70 Xplained Ultra board and the WM8904 Audio Codec Daughter Board, using the SSC PLIB: Jumper J204, which is next to the SAM E70 Xplained Ultra logo, should be jumpered for LED2.

To connect to the SSC, the jumpers (J6, J7, J8, and J9) on the WM8904 Codec Daughterboard must be oriented away from the pink, mic in, connector. See the red outlined jumpers in the below image as reference.



**Note:** The SAM E70 Xplained Ultra board does not include the WM8904 Audio Codec daughterboard, which is sold separately on microchipDIRECT as part number AC328904.

## Running the Demonstration

This section demonstrates how to run the demonstration.

### Description

**Important!** Prior to using this demonstration, it is recommended to review the MPLAB Harmony 3 Release Notes for any known issues.

Compile and program the target device. While compiling, select the appropriate MPLAB X IDE project. Refer to Building the Application for details.

Do the following to run the demonstration:

1. Attach the WM8904 Daughter Board to the X32 connector. Connect headphones to the HP OUT jack of the WM8904 Audio Codec Daughter Board (see Figure 1).

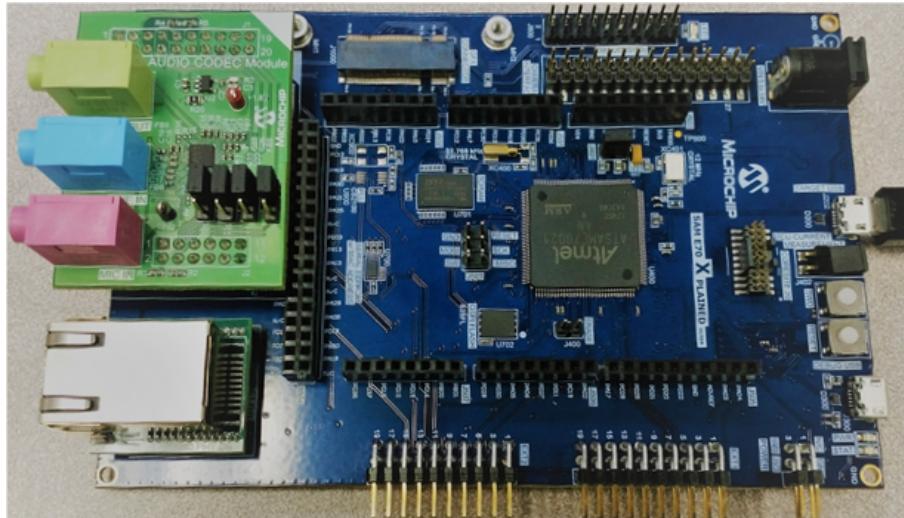


Figure 1. WM8904 Audio Codec Daughter Board on SAM E70 Xplained Ultra board. Headphone Out Jack is green.

2. Connect power to the board, compiles the application and program the target device. Run the device. The system will be in a waiting for USB to be connected (amber LED off).
3. Connect to the USB Host via the micro-mini connector located above the push-button switches on the right side of the board using a standard USB cable.
4. Allow the Host computer to acknowledge, install drivers (if needed), and enumerate the device. No special software is necessary on the Host side.

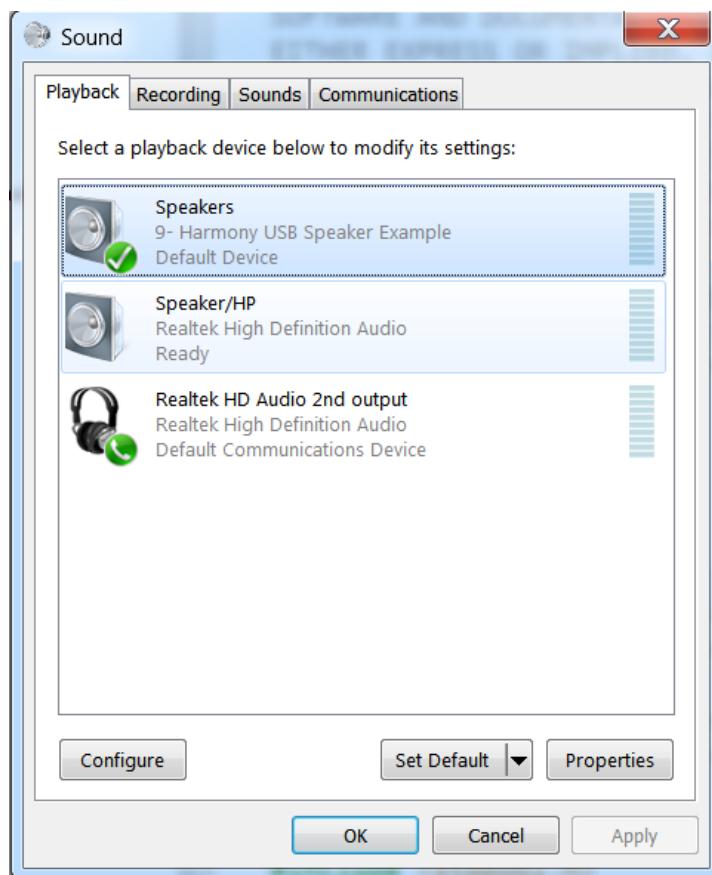


Figure 2. Windows 7 Sound Dialog showing USB Speaker with Sound Level Meter

5. If needed, configure the Host computer to use the `usb_speaker` outputs as the selected audio device. This may be done in the system configuration or "Control Panel" depending on the operating system. For Windows, this is done in the Playback Devices dialog, which is accessed by right clicking the loudspeaker icon in the taskbar.
6. Open a playback application (such as Window Media Player) and initiate playback through the USB Speaker.
7. Playback of the should demonstrate that the audio is being heard in the USB Speaker headphones.

### Control Description

Button control uses the push button function sequence given in the table below:

Function	Button Press
Volume Control Level 1	Low (-66 dB)
Volume Control Level 2	Medium (-48 dB)
Volume Control Level 3	High (0 dB)
Mute	Mute

Mute will transition to Volume Control Level 1 on the next button push.

USB operational status is given by LED, as shown below:

LED Indication	Status
OFF	USB cable detached
ON	USB cable attached
Blinking	Playback muted

# Audio Driver Libraries Help

## WM8904 CODEC Driver Library Help

This topic describes the WM8904 Codec Driver Library.

### Introduction

This library provides an Applications Programming Interface (API) to manage the WM8904 Codec that is serially interfaced to the I<sup>2</sup>C and I<sup>2</sup>S peripherals of a Microchip microcontroller for the purpose of providing audio solutions.

### Description

The WM8904 module is 24-bit Audio Codec from Cirrus Logic, which can operate in 16-, 20-, 24-, and 32-bit audio modes. The WM8904 can be interfaced to Microchip microcontrollers through I<sup>2</sup>C and I<sup>2</sup>S serial interfaces. The I<sup>2</sup>C interface is used to send commands and receive status, and the I<sup>2</sup>S interface is used for audio data output (to headphones or line-out) and input (from microphone or line-in).

The WM8904 can be configured as either an I<sup>2</sup>S clock slave (receives all clocks from the host), or I<sup>2</sup>S clock master (generates I<sup>2</sup>S clocks from a master clock input MCLK). Currently the driver only supports master mode with headphone output and (optionally) microphone input.

A typical interface of WM8904 to a Microchip microcontroller using an I<sup>2</sup>C and SSC interface (configured as I<sup>2</sup>S), with the WM8904 set up as the I<sup>2</sup>S clock master, is provided in the following diagram:

The WM8904 Codec supports the following features:

- Audio Interface Format: 16-/20-/24-/32-bit interface, LSB justified or I2S format (only 16 and 32-bit interfaces supported in the driver)
- Sampling Frequency Range: 8 kHz to 96 kHz
- Digital Volume Control: -71.625 to 0 dB in 192 steps (converted to a linear scale 0-255 in the driver)
- Soft mute capability

### Using the Library

This topic describes the basic architecture of the WM8904 Codec Driver Library and provides information and examples on its use.

### Description

**Interface Header File:** `drv_WM8904.h`

The interface to the WM8904 Codec Driver library is defined in the `audio/driver/codec/WM8904/drv_WM8904.h` header file. Any C language source (.c) file that uses the WM8904 Codec Driver library should include this header.

### Library Source Files:

The WM8904 Codec Driver library source files are provided in the `audio/driver/codec/WM8904/src` directory. This folder may contain optional files and alternate implementations. Please refer to **Configuring the Library** for instructions on how to select optional features and to **Building the Library** for instructions on how to build the library.

### Example Applications:

This library is used by the following applications, among others:

- `audio/apps/audio_tone`
- `audio/apps/audio_tone_linkeddma`
- `audio/apps/microphone_loopback`

### Abstraction Model

This library provides a low-level abstraction of the WM8904 Codec Driver Library on the Microchip family microcontrollers with a

convenient C language interface. This topic describes how that abstraction is modeled in software and introduces the library's interface.

## Description

The abstraction model shown in the following diagram depicts how the WM8904 Codec Driver is positioned in the MPLAB Harmony framework. The WM8904 Codec Driver uses the I2C and I2S drivers for control and audio data transfers to the WM8904 module.

**WM8904 Driver Abstraction Model**

## Library Overview

Refer to the Driver Library Overview section for information on how the driver operates in a system.

The WM8904 Codec Driver Library provides an API interface to transfer control commands and digital audio data to the serially interfaced WM8904 Codec module. The library interface routines are divided into various sub-sections, which address one of the blocks or the overall operation of the WM8904 Codec Driver Library.

Library Interface Section	Description
System Functions	Provides system module interfaces, device initialization, deinitialization, reinitialization, tasks and status functions.
Client Setup Functions	Provides open and close functions.
Data Transfer Functions	Provides data transfer functions, such as Buffer Read and Write.
Settings Functions	Provides driver specific functions for settings, such as volume control and sampling rate.
Other Functions	Miscellaneous functions, such as getting the driver's version number and syncing to the LRCLK signal.
Data Types and Constants	These data types and constants are required while interacting and setting up the WM8904 Codec Driver Library.



**Note:** All functions and constants in this section are named with the format `DRV_WM8904_xxx`, where 'xxx' is a function name or constant. These names are redefined in the appropriate configuration's `configuration.h` file to the format `DRV_CODEC_xxx` using #defines so that code in the application that references the library can be written as generically as possible (e.g., by writing `DRV_CODEC_Open` instead of `DRV_WM8904_Open` etc.). This allows the codec type to be changed in the MHC without having to modify the application's source code.

## How the Library Works

How the Library Works

The library provides interfaces to support:

- System Functionality
- Client Functionality

## Setup (Initialization)

This topic describes system initialization, implementations, and includes a system access code example.

## Description

### System Initialization

The system performs the initialization of the device driver with settings that affect only the instance of the device that is being initialized. During system initialization in the `system_init.c` file, each instance of the WM8904 module would be initialized with the following configuration settings (either passed dynamically at run time using `DRV_WM8904_INIT` or by using Initialization Overrides) that are supported by the specific WM8904 device hardware:

- Device requested power state: one of the System Module Power States. For specific details please refer to Data Types and Constants in the Library Interface section.
- I2C driver module index. The module index should be same as the one used in initializing the I2C Driver
- I2S driver module index. The module index should be same as the one used in initializing the I2S Driver
- Sampling rate
- Volume
- Audio data format. The audio data format should match with the audio data format settings done in I2S driver initialization
- Determines whether or not the microphone input is enabled

The [DRV\\_WM8904\\_Initialize](#) API returns an object handle of the type `SYS_MODULE_OBJ`. The object handle returned by the Initialize interface would be used by the other system interfaces such as `DRV_WM8904_Deinitialize`, `DRV_WM8904_Status` and `DRV_I2S_Tasks`.

## Client Access

This topic describes driver initialization and provides a code example.

### Description

For the application to start using an instance of the module, it must call the [DRV\\_WM8904\\_Open](#) function. The [DRV\\_WM8904\\_Open](#) function provides a driver handle to the WM8904 Codec Driver instance for operations. If the driver is deinitialized using the function [DRV\\_WM8904\\_Deinitialize](#), the application must call the [DRV\\_WM8904\\_Open](#) function again to set up the instance of the driver.

For the various options available for `IO_INTENT`, please refer to Data Types and Constants in the Library Interface section.

 **Note:** It is necessary to check the status of driver initialization before opening a driver instance. The status of the WM8904 Codec Driver can be known by calling `DRV_WM8904_Status`.

### Example:

```
DRV_HANDLE handle;
SYS_STATUS wm8904Status;
wm8904Status Status = DRV\_WM8904\_Status(sysObjects.wm8904Status DevObject);
if (SYS_STATUS_READY == wm8904Status)
{
    // The driver can now be opened.
    appData.wm8904Client.handle = DRV\_WM8904\_Open
    ( DRV_WM8904_INDEX_0, DRV_IO_INTENT_WRITE | DRV_IO_INTENT_EXCLUSIVE);
    if(appData.wm8904Client.handle != DRV_HANDLE_INVALID)
    {
        appData.state = APP_STATE_WM8904_SET_BUFFER_HANDLER;
    }
    else
    {
        SYS_DEBUG(0, "Find out what's wrong \r\n");
    }
}
else
{
    /* WM8904 Driver Is not ready */
}
```

## Client Operations

This topic provides information on client operations.

## Description

Client operations provide the API interface for control command and audio data transfer to the WM8904 Codec.

The following WM8904 Codec specific control command functions are provided:

- [DRV\\_WM8904\\_SamplingRateSet](#)
- [DRV\\_WM8904\\_SamplingRateGet](#)
- [DRV\\_WM8904\\_VolumeSet](#)
- [DRV\\_WM8904\\_VolumeGet](#)
- [DRV\\_WM8904\\_MuteOn](#)
- [DRV\\_WM8904\\_MuteOff](#)

These functions schedule a non-blocking control command transfer operation. These functions submit the control command request to the WM8904 Codec. These functions submit the control command request to I2C Driver transmit queue, the request is processed immediately if it is the first request, or processed when the previous request is complete.

[DRV\\_WM8904\\_BufferAddWrite](#), [DRV\\_WM8904\\_BufferAddRead](#), and [DRV\\_WM8904\\_BufferAddWriteRead](#) are buffered data operation functions. These functions schedule non-blocking audio data transfer operations. These functions add the request to I2S Driver transmit or receive buffer queue depends on the request type, and are executed immediately if it is the first buffer, or executed later when the previous buffer is complete. The driver notifies the client with [DRV\\_WM8904\\_BUFFER\\_EVENT\\_COMPLETE](#), [DRV\\_WM8904\\_BUFFER\\_EVENT\\_ERROR](#), or [DRV\\_WM8904\\_BUFFER\\_EVENT\\_ABORT](#) events.



**Note:** It is not necessary to close and reopen the client between multiple transfers.

## Configuring the Library

The configuration of the I2S Driver Library is based on the file `configurations.h`, as generated by the MHC.

This header file contains the configuration selection for the I2S Driver Library. Based on the selections made, the I2S Driver Library may support the selected features. These configuration settings will apply to all instances of the I2S Driver Library.

This header can be placed anywhere; however, the path of this header needs to be present in the include search path for a successful build. Refer to the Applications Help section for more details.

## System Configuration

### Macros

Name	Description
<a href="#">DRV_WM8904_AUDIO_DATA_FORMAT_MACRO</a>	Specifies the audio data format for the codec.
<a href="#">DRV_WM8904_AUDIO_SAMPLING_RATE</a>	Specifies the initial baud rate for the codec.
<a href="#">DRV_WM8904_CLIENTS_NUMBER</a>	Sets up the maximum number of clients that can be connected to any hardware instance.
<a href="#">DRV_WM8904_ENABLE_MIC_BIAS</a>	Specifies whether to enable the microphone bias.
<a href="#">DRV_WM8904_ENABLE_MIC_INPUT</a>	Specifies whether to enable the microphone input.
<a href="#">DRV_WM8904_I2C_DRIVER_MODULE_INDEX_IDXx</a>	Specifies the instance number of the I2C interface.
<a href="#">DRV_WM8904_I2S_DRIVER_MODULE_INDEX_IDXx</a>	Specifies the instance number of the I2S interface.
<a href="#">DRV_WM8904_INSTANCES_NUMBER</a>	Sets up the maximum number of hardware instances that can be supported
<a href="#">DRV_WM8904_MASTER_MODE</a>	Specifies if codec is in Master or Slave mode.
<a href="#">DRV_WM8904_VOLUME</a>	Specifies the initial volume level.

## Description

## DRV\_WM8904\_AUDIO\_DATA\_FORMAT\_MACRO Macro

Specifies the audio data format for the codec.

### Description

WM8904 Audio Data Format

Sets up the length of each sample plus the format (I2S or left-justified) for the audio.

Valid choices are: "DATA\_16\_BIT\_LEFT\_JUSTIFIED" "DATA\_16\_BIT\_I2S" "DATA\_32\_BIT\_LEFT\_JUSTIFIED"  
"DATA\_32\_BIT\_I2S"

### Remarks

If 24-bit audio is needed, it should be sent, left-justified, in a 32-bit format.

### C

```
#define DRV_WM8904_AUDIO_DATA_FORMAT_MACRO
```

## DRV\_WM8904\_AUDIO\_SAMPLING\_RATE Macro

Specifies the initial baud rate for the codec.

### Description

WM8904 Baud Rate

Sets the initial baud rate (sampling rate) for the codec. Typical values are 8000, 16000, 44100, 48000, 88200 and 96000.

### C

```
#define DRV_WM8904_AUDIO_SAMPLING_RATE
```

## DRV\_WM8904\_CLIENTS\_NUMBER Macro

Sets up the maximum number of clients that can be connected to any hardware instance.

### Description

WM8904 Client Count Configuration

Sets up the maximum number of clients that can be connected to any hardware instance. Typically only one client could be connected to one hardware instance. This value represents the total number of clients to be supported across all hardware instances.

### C

```
#define DRV_WM8904_CLIENTS_NUMBER
```

## DRV\_WM8904\_ENABLE\_MIC\_BIAS Macro

Specifies whether to enable the microphone bias.

### Description

WM8904 Microphone Enable

Indicates whether the bias voltage needed for electret microphones should be enabled.

### C

```
#define DRV_WM8904_ENABLE_MIC_BIAS
```

## DRV\_WM8904\_ENABLE\_MIC\_INPUT Macro

Specifies whether to enable the microphone input.

### Description

WM8904 Microphone Enable

Indicates whether the ADC inputs for the two microphone channels (L-R) should be enabled.

C

```
#define DRV_WM8904_ENABLE_MIC_INPUT
```

## DRV\_WM8904\_I2C\_DRIVER\_MODULE\_INDEX\_IDXx Macro

Specifies the instance number of the I2C interface.

### Description

WM8904 I2C instance number

Specifies the instance number of the I2C interface being used by the MCU to send commands and receive status to and from the WM8904. enabled.

C

```
#define DRV_WM8904_I2C_DRIVER_MODULE_INDEX_IDXx
```

## DRV\_WM8904\_I2S\_DRIVER\_MODULE\_INDEX\_IDXx Macro

Specifies the instance number of the I2S interface.

### Description

WM8904 I2S instance number

Specifies the instance number of the I2S interface being used by the MCU to send and receive audio data to and from the WM8904. enabled.

C

```
#define DRV_WM8904_I2S_DRIVER_MODULE_INDEX_IDXx
```

## DRV\_WM8904\_INSTANCES\_NUMBER Macro

Sets up the maximum number of hardware instances that can be supported

### Description

WM8904 driver objects configuration

Sets up the maximum number of hardware instances that can be supported. It is recommended that this number be set exactly equal to the number of WM8904 Codec modules that are needed by an application, namely one.

C

```
#define DRV_WM8904_INSTANCES_NUMBER
```

## DRV\_WM8904\_MASTER\_MODE Macro

Specifies if codec is in Master or Slave mode.

## Description

WM8904 Codec Master/Slave Mode

Indicates whether the codec is to be operating in a Master mode (generating word and bit clock as outputs) or Slave mode receiving word and bit clock as inputs).

## C

```
#define DRV_WM8904_MASTER_MODE
```

## DRV\_WM8904\_VOLUME Macro

Specifies the initial volume level.

## Description

WM8904 Volume

Sets the initial volume level, in the range 0-255.

## Remarks

The value is mapped to an internal WM8904 volume level in the range 0-192 using a logarithmic table so the input scale appears linear (128 is half volume).

## C

```
#define DRV_WM8904_VOLUME
```

## Configuring MHC

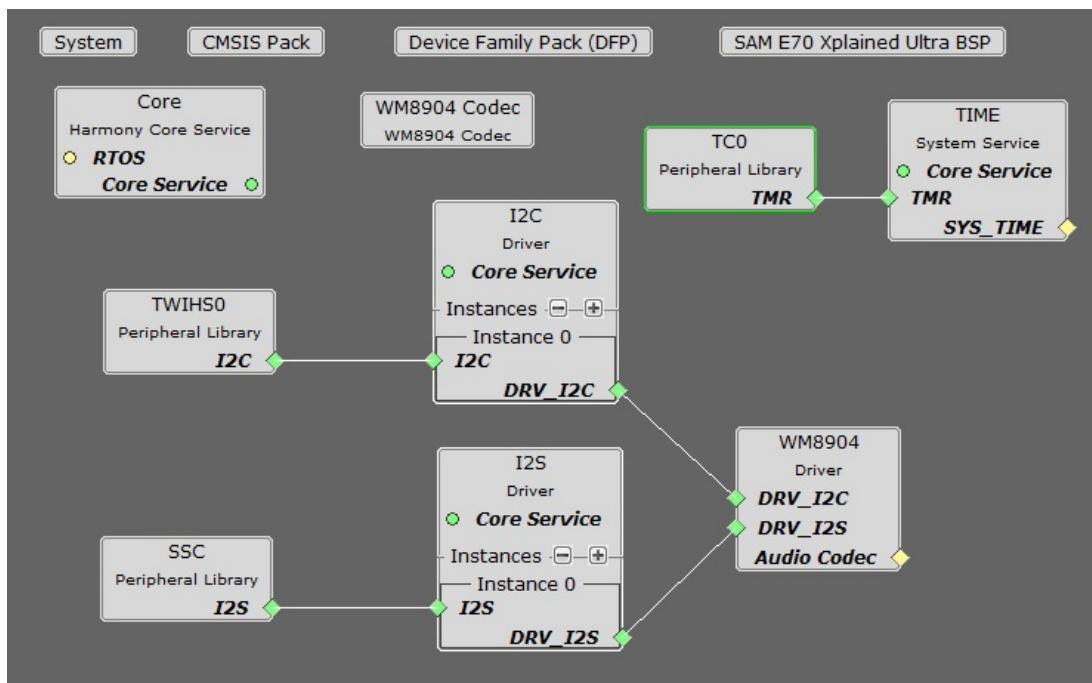
Provides examples on how to configure the MPLAB Harmony Configurator (MHC) for a specific driver.

## Description

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP, and select the appropriate processor (such as ATSAME70Q21B).

In the MHC, under Available Components select the appropriate BSP, such as SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on a codec template such as WM8904. Answer Yes to all questions.

You should end up with a project graph that looks like this, after rearranging the boxes:



Click on the WM8904 Driver component (not WM8904 Codec) and the following menu will be displayed in the Configurations Options:

- **I<sup>2</sup>C Driver Used** will display the driver instance used for the I<sup>2</sup>C interface.
- **I<sup>2</sup>S Driver Used** will display the driver instance used for the I<sup>2</sup>S interface.
- **Usage Mode** indicates whether the WM8904 is a Master (supplies I<sup>2</sup>S clocks) or a Slave (MCU supplies I<sup>2</sup>S clocks).
- **Number of WM8904 Clients** indicates the maximum number of clients that can be connected to the WM8904 Driver.
- **Sampling Rate** indicates the number of samples per second per channel, 8000 to 96,000.
- **Volume** indicates the volume in a linear scale from 0-255.
- **Audio Data Format** is either 16-bit Left Justified, 16-bit I2S, 32-bit Left Justified, or 32-bit I2S. It must match the audio protocol and data length set up in either the SSC or I2S PLIB.
- **Sampling Rate** indicates the number of samples per second per channel, 8000 to 96,000.
- **Enable Microphone Input** should be checked if a microphone is being used. If checked, another option,
- **Enable Microphone Bias** should be checked if using an electret microphone.

You can also bring in the WM8904 Driver by itself, by double clicking WM8904 under Audio->Driver->Codec in the Available Components list. You will then need to add any additional needed components manually and connect them together.

Note that the WM8904 requires the TCx Peripheral Library and TIME System Service in order to perform some of its internal timing sequences.

## Building the Library

This section lists the files that are available in the WM8904 Codec Driver Library.

### Description

This section lists the files that are available in the `src` folder of the WM8904 Codec Driver. It lists which files need to be included in the build based on either a hardware feature present on the board or configuration option selected by the system.

The following three tables list and describe the header (`.h`) and source (`.c`) files that implement this library. The parent folder for these files is `audio/driver/codec/WM8904`.

### Interface File(s)

This table lists and describes the header files that must be included (i.e., using `#include`) by any code that uses this library.

Source File Name	Description
<code>drv_wm8904.h</code>	Header file that exports the driver API.

## Required File(s)



*All of the required files listed in the following table are automatically added into the MPLAB X IDE project by the MHC when the library is selected for use.*

This table lists and describes the source and header files that must always be included in the MPLAB X IDE project to build this library.

Source File Name	Description
/src/drv_wm8904.c	This file contains implementation of the WM8904 Codec Driver.

## Optional File(s)

This table lists and describes the source and header files that may optionally be included if required for the desired implementation.

Source File Name	Description
N/A	No optional files are available for this library.

## Module Dependencies

The WM8904 Codec Driver Library depends on the following modules:

- I2S Driver Library
- I2C Driver Library

## Library Interface

### Client Setup Functions

	Name	Description
≡◊	DRV_WM8904_Open	Opens the specified WM8904 driver instance and returns a handle to it
≡◊	DRV_WM8904_Close	Closes an opened-instance of the WM8904 driver
≡◊	DRV_WM8904_BufferEventHandlerSet	This function allows a client to identify a buffer event handling function for the driver to call back when queued buffer transfers have finished.
≡◊	DRV_WM8904_CommandEventHandlerSet	This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

### Data Transfer Functions

	Name	Description
≡◊	DRV_WM8904_BufferAddRead	Schedule a non-blocking driver read operation.
≡◊	DRV_WM8904_BufferAddWrite	Schedule a non-blocking driver write operation.
≡◊	DRV_WM8904_BufferAddWriteRead	Schedule a non-blocking driver write-read operation.
≡◊	DRV_WM8904_ReadQueuePurge	Removes all buffer requests from the read queue.
≡◊	DRV_WM8904_WriteQueuePurge	Removes all buffer requests from the write queue.

### Data Types and Constants

	Name	Description
	DATA_LENGTH	in bits
	DRV_WM8904_AUDIO_DATA_FORMAT	Identifies the Serial Audio data interface format.
	DRV_WM8904_BUFFER_EVENT	Identifies the possible events that can result from a buffer add request.
	DRV_WM8904_BUFFER_EVENT_HANDLER	Pointer to a WM8904 Driver Buffer Event handler function
	DRV_WM8904_BUFFER_HANDLE	Handle identifying a write buffer passed to the driver.
	DRV_WM8904_CHANNEL	Identifies Left/Right Audio channel

	<a href="#">DRV_WM8904_COMMAND_EVENT_HANDLER</a>	Pointer to a WM8904 Driver Command Event Handler Function
	<a href="#">DRV_WM8904_INIT</a>	Defines the data required to initialize or reinitialize the WM8904 driver
	<a href="#">DRV_WM8904_BUFFER_HANDLE_INVALID</a>	Definition of an invalid buffer handle.
	<a href="#">DRV_WM8904_COUNT</a>	Number of valid WM8904 driver indices
	<a href="#">DRV_WM8904_INDEX_0</a>	WM8904 driver index definitions

## Other Functions

	Name	Description
≡	<a href="#">DRV_WM8904_GetI2SDriver</a>	Get the handle to the I2S driver for this codec instance.
≡	<a href="#">DRV_WM8904_VersionGet</a>	This function returns the version of WM8904 driver
≡	<a href="#">DRV_WM8904_VersionStrGet</a>	This function returns the version of WM8904 driver in string format.
≡	<a href="#">DRV_WM8904_LRCLK_Sync</a>	Synchronize to the start of the I2S LRCLK (left/right clock) signal

## Settings Functions

	Name	Description
≡	<a href="#">DRV_WM8904_MicGainGet</a>	This function gets the microphone gain for the WM8904 Codec.
≡	<a href="#">DRV_WM8904_MicGainSet</a>	This function sets the microphone gain for the WM8904 CODEC.
≡	<a href="#">DRV_WM8904_MicMuteOff</a>	Umutes th WM8904's microphone input.
≡	<a href="#">DRV_WM8904_MicMuteOn</a>	Mutes the WM8904's microphone input
≡	<a href="#">DRV_WM8904_MuteOff</a>	This function disables WM8904 output for soft mute.
≡	<a href="#">DRV_WM8904_MuteOn</a>	This function allows WM8904 output for soft mute on.
≡	<a href="#">DRV_WM8904_SamplingRateGet</a>	This function gets the sampling rate set on the WM8904.
≡	<a href="#">DRV_WM8904_SamplingRateSet</a>	This function sets the sampling rate of the media stream.
≡	<a href="#">DRV_WM8904_VolumeGet</a>	This function gets the volume for WM8904 Codec.
≡	<a href="#">DRV_WM8904_VolumeSet</a>	This function sets the volume for WM8904 Codec.

## System Interaction Functions

	Name	Description
≡	<a href="#">DRV_WM8904_Initialize</a>	Initializes hardware and data for the instance of the WM8904 DAC module
≡	<a href="#">DRV_WM8904_Deinitialize</a>	Deinitializes the specified instance of the WM8904 driver module
≡	<a href="#">DRV_WM8904_Status</a>	Gets the current status of the WM8904 driver module.
≡	<a href="#">DRV_WM8904_Tasks</a>	Maintains the driver's control and data interface state machine.

## System Interaction Functions

### DRV\_WM8904\_Initialize Function

```
SYS_MODULE_OBJ DRV_WM8904_Initialize
(
const SYS_MODULE_INDEX drvIndex,
const SYS_MODULE_INIT *const init
);
```

## Summary

Initializes hardware and data for the instance of the WM8904 DAC module

## Description

This routine initializes the WM8904 driver instance for the specified driver index, making it ready for clients to open and use it. The

initialization data is specified by the init parameter. The initialization may fail if the number of driver objects allocated are insufficient or if the specified driver instance is already initialized.

## Preconditions

DRV\_I2S\_Initialize must be called before calling this function to initialize the data interface of this Codec driver.  
DRV\_I2C\_Initialize must be called if SPI driver is used for handling the control interface of this Codec driver.

## Parameters

Parameters	Description
drvIndex	Identifier for the driver instance to be initialized
init	Pointer to the data structure containing any data necessary to initialize the hardware. This pointer may be null if no data is required and default initialization is to be used.

## Returns

If successful, returns a valid handle to a driver instance object. Otherwise, it returns SYS\_MODULE\_OBJ\_INVALID.

## Remarks

This routine must be called before any other WM8904 routine is called.

This routine should only be called once during system initialization unless [DRV\\_WM8904\\_Deinitialize](#) is called to deinitialize the driver instance. This routine will NEVER block for hardware access.

## Example

```
DRV_WM8904_INIT          init;
SYS_MODULE_OBJ            objectHandle;

init->inUse              = true;
init->status              = SYS_STATUS_BUSY;
init->numClients          = 0;
init->i2sDriverModuleIndex = wm8904Init->i2sDriverModuleIndex;
init->i2cDriverModuleIndex = wm8904Init->i2cDriverModuleIndex;
init->samplingRate         = DRV_WM8904_AUDIO_SAMPLING_RATE;
init->audioDataFormat     = DRV_WM8904_AUDIO_DATA_FORMAT_MACRO;

init->isInInterruptContext = false;

init->commandCompleteCallback = (DRV_WM8904_COMMAND_EVENT_HANDLER)0;
init->commandContextData = 0;
init->mclk_multiplier = DRV_WM8904_MCLK_SAMPLE_FREQ_MULTIPLIER;

objectHandle = DRV_WM8904_Initialize(DRV_WM8904_0, (SYS_MODULE_INIT*)init);
if (SYS_MODULE_OBJ_INVALID == objectHandle)
{
    // Handle error
}
```

## C

```
SYS_MODULE_OBJ DRV_WM8904_Initialize(const SYS_MODULE_INDEX drvIndex, const SYS_MODULE_INIT * const init);
```

## DRV\_WM8904\_Deinitialize Function

```
void DRV_WM8904_Deinitialize(SYS_MODULE_OBJ object)
```

## Summary

Deinitializes the specified instance of the WM8904 driver module

## Description

Deinitializes the specified instance of the WM8904 driver module, disabling its operation (and any hardware). Invalidates all the

internal data.

## Preconditions

Function [DRV\\_WM8904\\_Initialize](#) should have been called before calling this function.

## Parameters

Parameters	Description
object	Driver object handle, returned from the <a href="#">DRV_WM8904_Initialize</a> routine

## Returns

None.

## Remarks

Once the Initialize operation has been called, the De-initialize operation must be called before the Initialize operation can be called again. This routine will NEVER block waiting for hardware.

## Example

```
SYS_MODULE_OBJ          object;      // Returned from DRV_WM8904_Initialize
SYS_STATUS              status;

DRV_WM8904_Deinitialize(object);

status = DRV_WM8904_Status(object);
if (SYS_MODULE_DEINITIALIZED != status)
{
    // Check again later if you need to know
    // when the driver is deinitialized.
}
```

## C

```
void DRV_WM8904_Deinitialize(SYS_MODULE_OBJ object);
```

## DRV\_WM8904\_Status Function

SYS\_STATUS DRV\_WM8904\_Status( SYS\_MODULE\_OBJ object)

## Summary

Gets the current status of the WM8904 driver module.

## Description

This routine provides the current status of the WM8904 driver module.

## Preconditions

Function [DRV\\_WM8904\\_Initialize](#) should have been called before calling this function.

## Parameters

Parameters	Description
object	Driver object handle, returned from the <a href="#">DRV_WM8904_Initialize</a> routine

## Returns

SYS\_STATUS\_DEINITIALIZED - Indicates that the driver has been deinitialized

SYS\_STATUS\_READY - Indicates that any previous module operation for the specified module has completed

SYS\_STATUS\_BUSY - Indicates that a previous module operation for the specified module has not yet completed

SYS\_STATUS\_ERROR - Indicates that the specified module is in an error state

## Remarks

A driver can be opened only when its status is SYS\_STATUS\_READY.

## Example

```
SYS_MODULE_OBJ      object;      // Returned from DRV_WM8904_Initialize
SYS_STATUS          WM8904Status;

WM8904Status = DRV_WM8904_Status(object);
if (SYS_STATUS_READY == WM8904Status)
{
    // This means the driver can be opened using the
    // DRV_WM8904_Open() function.
}
```

## C

```
SYS_STATUS DRV_WM8904_Status(SYS_MODULE_OBJ object);
```

## DRV\_WM8904\_Tasks Function

```
void DRV_WM8904_Tasks(SYS_MODULE_OBJ object);
```

## Summary

Maintains the driver's control and data interface state machine.

## Description

This routine is used to maintain the driver's internal control and data interface state machine and implement its control and data interface implementations. This function should be called from the SYS\_Tasks() function.

## Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

## Parameters

Parameters	Description
object	Object handle for the specified driver instance (returned from <a href="#">DRV_WM8904_Initialize</a> )

## Returns

None.

## Remarks

This routine is normally not called directly by an application. It is called by the system's Tasks routine (SYS\_Tasks).

## Example

```
SYS_MODULE_OBJ      object;      // Returned from DRV_WM8904_Initialize

while (true)
{
    DRV_WM8904_Tasks (object);

    // Do other tasks
}
```

## C

```
void DRV_WM8904_Tasks(SYS_MODULE_OBJ object);
```

## Client Setup Functions

## DRV\_WM8904\_Open Function

```
DRV_HANDLE DRV_WM8904_Open
(
const SYS_MODULE_INDEX drvIndex,
const DRV_IO_INTENT ioIntent
)
```

### Summary

Opens the specified WM8904 driver instance and returns a handle to it

### Description

This routine opens the specified WM8904 driver instance and provides a handle that must be provided to all other client-level operations to identify the caller and the instance of the driver. The ioIntent parameter defines how the client interacts with this driver instance.

The DRV\_IO\_INTENT\_BLOCKING and DRV\_IO\_INTENT\_NONBLOCKING ioIntent options are not relevant to this driver. All the data transfer functions of this driver are non blocking.

The WM8904 can be opened with DRV\_IO\_INTENT\_WRITE, or DRV\_IO\_INTENT\_READ or DRV\_IO\_INTENT\_WRITEREAD io\_intent option. This decides whether the driver is used for headphone output, or microphone input or both modes simultaneously.

Specifying a DRV\_IO\_INTENT\_EXCLUSIVE will cause the driver to provide exclusive access to this client. The driver cannot be opened by any other client.

### Preconditions

Function [DRV\\_WM8904\\_Initialize](#) must have been called before calling this function.

### Parameters

Parameters	Description
drvIndex	Identifier for the object instance to be opened
ioIntent	Zero or more of the values from the enumeration DRV_IO_INTENT "ORed" together to indicate the intended use of the driver. See function description for details.

### Returns

If successful, the routine returns a valid open-instance handle (a number identifying both the caller and the module instance).

If an error occurs, the return value is DRV\_HANDLE\_INVALID. Error can occur:

- if the number of client objects allocated via [DRV\\_WM8904\\_CLIENTS\\_NUMBER](#) is insufficient.
- if the client is trying to open the driver but driver has been opened exclusively by another client.
- if the driver hardware instance being opened is not initialized or is invalid.
- if the ioIntent options passed are not relevant to this driver.

### Remarks

The handle returned is valid until the [DRV\\_WM8904\\_Close](#) routine is called. This routine will NEVER block waiting for hardware. If the requested intent flags are not supported, the routine will return DRV\_HANDLE\_INVALID. This function is thread safe in a RTOS application. It should not be called in an ISR.

### Example

```
DRV_HANDLE handle;

handle = DRV_WM8904_Open(DRV_WM8904_INDEX_0, DRV_IO_INTENT_WRITEREAD | DRV_IO_INTENT_EXCLUSIVE);
if (DRV_HANDLE_INVALID == handle)
{
    // Unable to open the driver
    // May be the driver is not initialized or the initialization
    // is not complete.
}
```

**C**

```
DRV_HANDLE DRV_WM8904_Open(const SYS_MODULE_INDEX iDriver, const DRV_IO_INTENT ioIntent);
```

**DRV\_WM8904\_Close Function**

```
void DRV_WM8904_Close( DRV_Handle handle )
```

**Summary**

Closes an opened-instance of the WM8904 driver

**Description**

This routine closes an opened-instance of the WM8904 driver, invalidating the handle. Any buffers in the driver queue that were submitted by this client will be removed. After calling this routine, the handle passed in "handle" must not be used with any of the remaining driver routines. A new handle must be obtained by calling [DRV\\_WM8904\\_Open](#) before the caller may use the driver again

**Preconditions**

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

**Returns**

- None

**Remarks**

Usually there is no need for the driver client to verify that the Close operation has completed. The driver will abort any ongoing operations when this routine is called.

**Example**

```
DRV_HANDLE handle; // Returned from DRV_WM8904_Open
DRV_WM8904_Close(handle);
```

**C**

```
void DRV_WM8904_Close(const DRV_HANDLE handle);
```

**DRV\_WM8904\_BufferEventHandlerSet Function**

```
void DRV_WM8904_BufferEventHandlerSet
(
    DRV_HANDLE handle,
    const DRV_WM8904_BUFFER_EVENT_HANDLER eventHandler,
    const uintptr_t contextHandle
)
```

**Summary**

This function allows a client to identify a buffer event handling function for the driver to call back when queued buffer transfers have finished.

**Description**

When a client calls [DRV\\_WM8904\\_BufferAddWrite](#) function, it is provided with a handle identifying the buffer that was added to

the driver's buffer queue. The driver will pass this handle back to the client by calling "eventHandler" function when the buffer transfer has completed.

The event handler should be set before the client performs any "buffer add" operations that could generate events. The event handler once set, persists until the client closes the driver or sets another event handler (which could be a "NULL" pointer to indicate no callback).

## Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
eventHandler	Pointer to the event handler function.
context	The value of parameter will be passed back to the client unchanged, when the eventHandler function is called. It can be used to identify any client specific data object that identifies the instance of the client module (for example, it may be a pointer to the client module's state structure).

## Returns

None.

## Remarks

If the client does not want to be notified when the queued buffer transfer has completed, it does not need to register a callback.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_WM8904_BUFFER_HANDLE bufferHandle;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

// Client registers an event handler with driver

DRV_WM8904_BufferEventHandlerSet(myWM8904Handle,
                                  APP_WM8904BufferEventHandler, (uintptr_t)&myAppObj);

DRV_WM8904_BufferAddWrite(myWM8904Handle, &bufferHandle
                           myBuffer, MY_BUFFER_SIZE);

if(DRV_WM8904_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void APP_WM8904BufferEventHandler(DRV_WM8904_BUFFER_EVENT event,
                                   DRV_WM8904_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_WM8904_BUFFER_EVENT_COMPLETE:

            // This means the data was transferred.
            break;

        case DRV_WM8904_BUFFER_EVENT_ERROR:
    }
}

```

```

    // Error handling here.
    break;

    default:
        break;
}
}

```

**C**

```
void DRV_WM8904_BufferEventHandlerSet(DRV_HANDLE handle, const DRV_WM8904_BUFFER_EVENT_HANDLER eventHandler, const uintptr_t contextHandle);
```

**DRV\_WM8904\_CommandEventHandlerSet Function**

```
void DRV_WM8904_CommandEventHandlerSet
(
    DRV_HANDLE handle,
    const     DRV_WM8904_COMMAND_EVENT_HANDLER eventHandler,
    const uintptr_t contextHandle
)
```

**Summary**

This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

**Description**

This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

The event handler should be set before the client performs any "WM8904 Codec Specific Client Routines" operations that could generate events. The event handler once set, persists until the client closes the driver or sets another event handler (which could be a "NULL" pointer to indicate no callback).

**Preconditions**

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
eventHandler	Pointer to the event handler function.
context	The value of parameter will be passed back to the client unchanged, when the eventHandler function is called. It can be used to identify any client specific data object that identifies the instance of the client module (for example, it may be a pointer to the client module's state structure).

**Returns**

None.

**Remarks**

If the client does not want to be notified when the command has completed, it does not need to register a callback.

**Example**

```
MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_WM8904_BUFFER_HANDLE bufferHandle;
```

```

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

// Client registers an event handler with driver

DRV_WM8904_CommandEventHandlerSet(myWM8904Handle,
    APP_WM8904CommandEventHandler, (uintptr_t)&myAppObj);

DRV_WM8904_DeEmphasisFilterSet(myWM8904Handle, DRV_WM8904_DEEMPHASIS_FILTER_44_1KHZ)

// Event is received when
// the buffer is processed.

void APP_WM8904CommandEventHandler(uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        // Last Submitted command is completed.
        // Perform further processing here
    }
}

```

**C**

```

void DRV_WM8904_CommandEventHandlerSet(DRV_HANDLE handle, const
DRV_WM8904_COMMAND_EVENT_HANDLER eventHandler, const uintptr_t contextHandle);

```

**Data Transfer Functions****DRV\_WM8904\_BufferAddRead Function**

```

void DRV_WM8904_BufferAddRead
(
    const DRV_HANDLE handle,
    DRV_WM8904_BUFFER_HANDLE *bufferHandle,
    void *buffer, size_t size
)

```

**Summary**

Schedule a non-blocking driver read operation.

**Description**

This function schedules a non-blocking read operation. The function returns with a valid buffer handle in the bufferHandle argument if the read request was scheduled successfully. The function adds the request to the hardware instance receive queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns **DRV\_WM8904\_BUFFER\_HANDLE\_INVALID**

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the buffer size is 0.
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a **DRV\_WM8904\_BUFFER\_EVENT\_COMPLETE** event if the buffer was processed successfully or **DRV\_WM8904\_BUFFER\_EVENT\_ERROR** event if the buffer was not processed successfully.

## Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 device instance and the [DRV\\_WM8904\\_Status](#) must have returned [SYS\\_STATUS\\_READY](#).

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

[DRV\\_IO\\_INTENT\\_READ](#) must have been specified in the [DRV\\_WM8904\\_Open](#) call.

## Parameters

Parameters	Description
handle	Handle of the WM8904 instance as return by the <a href="#">DRV_WM8904_Open</a> function.
buffer	Data to be transmitted.
size	Buffer size in bytes.
bufferHandle	Pointer to an argument that will contain the return buffer handle.

## Returns

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_WM8904\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

## Remarks

This function is thread safe in a RTOS application. It can be called from within the WM8904 Driver Buffer Event Handler that is registered by this client. It should not be called in the event handler associated with another WM8904 driver instance. It should not otherwise be called directly in an ISR.

## C

```
void DRV_WM8904_BufferAddRead(const DRV_HANDLE handle, DRV_WM8904_BUFFER_HANDLE * bufferHandle,
                               void * buffer, size_t size);
```

## DRV\_WM8904\_BufferAddWrite Function

```
void DRV_WM8904_BufferAddWrite
(
    const DRV_HANDLE handle,
    DRV_WM8904_BUFFER_HANDLE *bufferHandle,
    void *buffer, size_t size
)
```

## Summary

Schedule a non-blocking driver write operation.

## Description

This function schedules a non-blocking write operation. The function returns with a valid buffer handle in the bufferHandle argument if the write request was scheduled successfully. The function adds the request to the hardware instance transmit queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns [DRV\\_WM8904\\_BUFFER\\_HANDLE\\_INVALID](#):

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the buffer size is 0.
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a [DRV\\_WM8904\\_BUFFER\\_EVENT\\_COMPLETE](#) event if the buffer was processed successfully or [DRV\\_WM8904\\_BUFFER\\_EVENT\\_ERROR](#) event if the buffer was not processed successfully.

## Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 device instance and the [DRV\\_WM8904\\_Status](#) must have returned [SYS\\_STATUS\\_READY](#).

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

DRV\_IO\_INTENT\_WRITE must have been specified in the [DRV\\_WM8904\\_Open](#) call.

## Parameters

Parameters	Description
handle	Handle of the WM8904 instance as return by the <a href="#">DRV_WM8904_Open</a> function.
buffer	Data to be transmitted.
size	Buffer size in bytes.
bufferHandle	Pointer to an argument that will contain the return buffer handle.

## Returns

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_WM8904\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

## Remarks

This function is thread safe in a RTOS application. It can be called from within the WM8904 Driver Buffer Event Handler that is registered by this client. It should not be called in the event handler associated with another WM8904 driver instance. It should not otherwise be called directly in an ISR.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_WM8904_BUFFER_HANDLE bufferHandle;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

// Client registers an event handler with driver

DRV_WM8904_BufferEventHandlerSet(myWM8904Handle,
                                  APP_WM8904BufferEventHandler, (uintptr_t)&myAppObj);

DRV_WM8904_BufferAddWrite(myWM8904Handle, &bufferHandle
                           myBuffer, MY_BUFFER_SIZE);

if(DRV_WM8904_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void APP_WM8904BufferEventHandler(DRV_WM8904_BUFFER_EVENT event,
                                   DRV_WM8904_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_WM8904_BUFFER_EVENT_COMPLETE:

            // This means the data was transferred.
            break;

        case DRV_WM8904_BUFFER_EVENT_ERROR:

            // Error handling here.
            break;

        default:
            break;
    }
}

```

```
}
```

## C

```
void DRV_WM8904_BufferAddWrite(const DRV_HANDLE handle, DRV_WM8904_BUFFER_HANDLE *bufferHandle, void * buffer, size_t size);
```

### DRV\_WM8904\_BufferAddWrite Read Function

```
void DRV_WM8904_BufferAddWriteRead
(
    const DRV_HANDLE handle,
    DRV_WM8904_BUFFER_HANDLE *bufferHandle,
    void *transmitBuffer,
    void *receiveBuffer,
    size_t size
)
```

### Summary

Schedule a non-blocking driver write-read operation.

### Description

This function schedules a non-blocking write-read operation. The function returns with a valid buffer handle in the bufferHandle argument if the write-read request was scheduled successfully. The function adds the request to the hardware instance queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns DRV\_WM8904\_BUFFER\_EVENT\_COMPLETE:

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the client opened the driver for read only or write only
- if the buffer size is 0
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a DRV\_WM8904\_BUFFER\_EVENT\_COMPLETE event if the buffer was processed successfully or DRV\_WM8904\_BUFFER\_EVENT\_ERROR event if the buffer was not processed successfully.

### Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 device instance and the [DRV\\_WM8904\\_Status](#) must have returned SYS\_STATUS\_READY.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

[DRV\\_IO\\_INTENT\\_READWRITE](#) must have been specified in the [DRV\\_WM8904\\_Open](#) call.

### Parameters

Parameters	Description
handle	Handle of the WM8904 instance as returned by the <a href="#">DRV_WM8904_Open</a> function
bufferHandle	Pointer to an argument that will contain the return buffer handle
transmitBuffer	The buffer where the transmit data will be stored
receiveBuffer	The buffer where the received data will be stored
size	Buffer size in bytes

### Returns

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_WM8904\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

### Remarks

This function is thread safe in a RTOS application. It can be called from within the WM8904 Driver Buffer Event Handler that is

registered by this client. It should not be called in the event handler associated with another WM8904 driver instance. It should not otherwise be called directly in an ISR.

This function is useful when there is valid read expected for every WM8904 write. The transmit and receive size must be same.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybufferTx[MY_BUFFER_SIZE];
uint8_t mybufferRx[MY_BUFFER_SIZE];
DRV_WM8904_BUFFER_HANDLE bufferHandle;

// mywm8904Handle is the handle returned
// by the DRV_WM8904_Open function.

// Client registers an event handler with driver

DRV_WM8904_BufferEventHandlerSet(mywm8904Handle,
                                  APP_WM8904BufferEventHandler, (uintptr_t)&myAppObj);

DRV_WM8904_BufferAddWriteRead(mywm8904Handle, &bufferHandle,
                               mybufferTx, mybufferRx, MY_BUFFER_SIZE);

if(DRV_WM8904_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void APP_WM8904BufferEventHandler(DRV_WM8904_BUFFER_EVENT event,
                                    DRV_WM8904_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_WM8904_BUFFER_EVENT_COMPLETE:

            // This means the data was transferred.
            break;

        case DRV_WM8904_BUFFER_EVENT_ERROR:

            // Error handling here.
            break;

        default:
            break;
    }
}

```

## C

```

void DRV_WM8904_BufferAddWriteRead(const DRV_HANDLE handle, DRV_WM8904_BUFFER_HANDLE *  
bufferHandle, void * transmitBuffer, void * receiveBuffer, size_t size);

```

## DRV\_WM8904\_ReadQueuePurge Function

```
bool DRV_WM8904_ReadQueuePurge( const DRV_HANDLE handle )
```

## Summary

Removes all buffer requests from the read queue.

## Description

This function removes all the buffer requests from the read queue. The client can use this function to purge the queue on timeout or to remove unwanted stalled buffer requests or in any other use case.

## Preconditions

[DRV\\_I2S\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	Handle of the communication channel as returned by the <a href="#">DRV_WM8904_Open</a> function.

## Returns

True - Read queue purge is successful. False - Read queue purge has failed.

## Remarks

This function is thread safe when used in an RTOS environment. Avoid this function call from within the callback.

## Example

```
// myCodecHandle is the handle returned by the DRV_WM8904_Open function.
// Use DRV_WM8904_BufferAddRead to queue read requests

// Application timeout function, where remove queued buffers.
void APP_TimeOut(void)
{
    if(false == DRV_WM8904_ReadQueuePurge(myCodecHandle))
    {
        //Couldn't purge the read queue, try again.
    }
    else
    {
        //Queue purge successful.
    }
}
```

## C

```
bool DRV_WM8904_ReadQueuePurge(const DRV_HANDLE handle);
```

## DRV\_WM8904\_WriteQueuePurge Function

```
bool DRV_WM8904_WriteQueuePurge( const DRV_HANDLE handle )
```

## Summary

Removes all buffer requests from the write queue.

## Description

This function removes all the buffer requests from the write queue. The client can use this function to purge the queue on timeout or to remove unwanted stalled buffer requests or in any other use case.

## Preconditions

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	Handle of the communication channel as returned by the <a href="#">DRV_WM8904_Open</a> function.

## Returns

True - Write queue purge is successful. False - Write queue purge has failed.

## Remarks

This function is thread safe when used in an RTOS environment. Avoid this function call from within the callback.

## Example

```
// myCodecHandle is the handle returned by the DRV_WM8904_Open function.
// Use DRV_WM8904_BufferAddWrite to queue write requests

// Application timeout function, where remove queued buffers.
void APP_TimeOut(void)
{
    if(false == DRV_WM8904_WriteQueuePurge(myCodecHandle))
    {
        //Couldn't purge the write queue, try again.
    }
    else
    {
        //Queue purge successful.
    }
}
```

## C

```
bool DRV_WM8904_WriteQueuePurge(const DRV_HANDLE handle);
```

## Settings Functions

### DRV\_WM8904\_MicGainGet Function

```
uint8_t DRV_WM8904_MicGainGet(DRV_HANDLE handle)
```

## Summary

This function gets the microphone gain for the WM8904 Codec.

## Description

This functions gets the current microphone gain programmed to the Codec WM8904.

## Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

Microphone gain, in range 0-31.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;
```

```

uint8_t gain;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

gain = DRV_WM8904_MicGainGet(myWM8904Handle);

```

**C**

```
uint8_t DRV_WM8904_MicGainGet(DRV_HANDLE handle);
```

**DRV\_WM8904\_MicGainSet Function**

```
void DRV_WM8904_MicGainSet(DRV_HANDLE handle, uint8_t gain)
```

**Summary**

This function sets the microphone gain for the WM8904 CODEC.

**Description**

This functions sets the microphone gain value from 0-31 which can range from -1.5 to 28.3 dB

**Preconditions**

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
gain	Gain value, in range 0-31

**Returns**

None.

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;
```

```
// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.
```

```
DRV_WM8904_MicGainSet(myWM8904Handle, 15); //WM8904 mic gain set to 15
```

**Remarks**

None.

**C**

```
void DRV_WM8904_MicGainSet(DRV_HANDLE handle, uint8_t gain);
```

**DRV\_WM8904\_MicMuteOff Function**

```
void DRV_WM8904_MicMuteOff(DRV_HANDLE handle)
```

**Summary**

Umutes th WM8904's microphone input.

**Description**

This function unmutes the WM8904's microphone input.

**Preconditions**

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

DRV_WM8904_MicMuteOff(myWM8904Handle); //WM8904 microphone unmuted
```

## C

```
void DRV_WM8904_MicMuteOff(DRV_HANDLE handle);
```

## DRV\_WM8904\_MicMuteOn Function

```
void DRV_WM8904_MicMuteOn(DRV_HANDLE handle);
```

## Summary

Mutes the WM8904's microphone input

## Description

This function mutes the WM8904's microphone input

## Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

DRV_WM8904_MicMuteOn(myWM8904Handle); //WM8904 microphone muted
```

**C**

```
void DRV_WM8904_MicMuteOn(DRV_HANDLE handle);
```

**DRV\_WM8904\_MuteOff Function**

```
void DRV_WM8904_MuteOff(DRV_HANDLE handle)
```

**Summary**

This function disables WM8904 output for soft mute.

**Description**

This function disables WM8904 output for soft mute.

**Preconditions**

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

**Returns**

None.

**Remarks**

None.

**Example**

```
// myAppObj is an application specific object.  
MY_APP_OBJ myAppObj;  
  
uint8_t mybuffer[MY_BUFFER_SIZE];  
DRV_BUFFER_HANDLE bufferHandle;  
  
// myWM8904Handle is the handle returned  
// by the DRV_WM8904_Open function.  
  
DRV_WM8904_MuteOff(myWM8904Handle); //WM8904 output soft mute disabled
```

**C**

```
void DRV_WM8904_MuteOff(DRV_HANDLE handle);
```

**DRV\_WM8904\_MuteOn Function**

```
void DRV_WM8904_MuteOn(DRV_HANDLE handle);
```

**Summary**

This function allows WM8904 output for soft mute on.

**Description**

This function Enables WM8904 output for soft mute.

**Preconditions**

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_BUFFER_HANDLE bufferHandle;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

DRV_WM8904_MuteOn(myWM8904Handle); //WM8904 output soft muted
```

## C

```
void DRV_WM8904_MuteOn(DRV_HANDLE handle);
```

## DRV\_WM8904\_SamplingRateGet Function

```
uint32_t DRV_WM8904_SamplingRateGet(DRV_HANDLE handle)
```

## Summary

This function gets the sampling rate set on the WM8904.

## Description

This function gets the sampling rate set on the DAC WM8904.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Remarks

None.

## Example

```
uint32_t baudRate;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

baudRate = DRV_WM8904_SamplingRateGet(myWM8904Handle);
```

## C

```
uint32_t DRV_WM8904_SamplingRateGet(DRV_HANDLE handle);
```

## DRV\_WM8904\_SamplingRateSet Function

```
void DRV_WM8904_SamplingRateSet(DRV_HANDLE handle, uint32_t samplingRate)
```

## Summary

This function sets the sampling rate of the media stream.

## Description

This function sets the media sampling rate for the client handle.

## Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
samplingRate	Sampling frequency in Hz

## Returns

None.

## Remarks

None.

## Example

```
// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

DRV_WM8904_SamplingRateSet(myWM8904Handle, 48000); //Sets 48000 media sampling rate
```

## C

```
void DRV_WM8904_SamplingRateSet(DRV_HANDLE handle, uint32_t samplingRate);
```

## DRV\_WM8904\_VolumeGet Function

```
uint8_t DRV_WM8904_VolumeGet(DRV_HANDLE handle, DRV_WM8904_CHANNEL channel)
```

## Summary

This function gets the volume for WM8904 Codec.

## Description

This functions gets the current volume programmed to the Codec WM8904.

## Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
channel	argument indicating Left or Right or Both channel volume to be modified

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;
uint8_t volume;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

volume = DRV_WM8904_VolumeGet(myWM8904Handle, DRV_WM8904_CHANNEL_LEFT);
```

## C

```
uint8_t DRV_WM8904_VolumeGet(DRV_HANDLE handle, DRV_WM8904_CHANNEL channel);
```

## DRV\_WM8904\_VolumeSet Function

void DRV\_WM8904\_VolumeSet(DRV\_HANDLE handle, [DRV\\_WM8904\\_CHANNEL](#) channel, uint8\_t volume);

### Summary

This function sets the volume for WM8904 Codec.

### Description

This function sets the volume value from 0-255. The codec has DAC value to volume range mapping as :- 00 H : +12dB FF H : -115dB In order to make the volume value to dB mapping monotonically increasing from 00 to FF, re-mapping is introduced which reverses the volume value to dB mapping as well as normalizes the volume range to a more audible dB range. The current driver implementation assumes that all dB values under -60 dB are inaudible to the human ear. Re-Mapped values 00 H : -60 dB FF H : +12 dB

### Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

### Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
channel	argument indicating Left or Right or Both channel volume to be modified
volume	volume value specified in the range 0-255 (0x00 to 0xFF)

### Returns

None

### Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_BUFFER_HANDLE bufferHandle;

// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

DRV_WM8904_VolumeSet(myWM8904Handle,DRV_WM8904_CHANNEL_LEFT, 120);

void DRV_WM8904_VolumeSet(DRV_HANDLE handle, DRV_WM8904_CHANNEL channel, uint8_t volume);
```

## C

```
void DRV_WM8904_VolumeSet(DRV_HANDLE handle, DRV_WM8904_CHANNEL channel, uint8_t volume);
```

## Other Functions

### DRV\_WM8904\_GetI2SDriver Function

```
DRV_HANDLE DRV_WM8904_GetI2SDriver(DRV_HANDLE codecHandle)
```

#### Summary

Get the handle to the I2S driver for this codec instance.

#### Description

Returns the appropriate handle to the I2S based on the iolent member of the codec object.

#### Preconditions

The [DRV\\_WM8904\\_Initialize](#) routine must have been called for the specified WM8904 driver instance.

[DRV\\_WM8904\\_Open](#) must have been called to obtain a valid opened device handle.

#### Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

#### Returns

A handle to the I2S driver for this codec instance

#### Remarks

This allows the caller to directly access portions of the I2S driver that might not be available via the codec API.

#### C

```
DRV_HANDLE DRV_WM8904_GetI2SDriver(DRV_HANDLE codecHandle);
```

### DRV\_WM8904\_VersionGet Function

```
uint32_t DRV_WM8904_VersionGet( void )
```

#### Summary

This function returns the version of WM8904 driver

#### Description

The version number returned from the DRV\_WM8904\_VersionGet function is an unsigned integer in the following decimal format.  
 $* 10000 + * 100 +$  Where the numbers are represented in decimal and the meaning is the same as above. Note that there is no numerical representation of release type.

#### Preconditions

None.

#### Returns

returns the version of WM8904 driver.

#### Remarks

None.

#### Example 1

For version "0.03a", return:  $0 * 10000 + 3 * 100 + 0$  For version "1.00", return:  $1 * 100000 + 0 * 100 + 0$

## Example 2

```
uint32_t WM8904version;
WM8904version = DRV_WM8904_VersionGet();
```

### C

```
uint32_t DRV_WM8904_VersionGet();
```

## DRV\_WM8904\_VersionStrGet Function

```
int8_t* DRV_WM8904_VersionStrGet(void)
```

### Summary

This function returns the version of WM8904 driver in string format.

### Description

The DRV\_WM8904\_VersionStrGet function returns a string in the format: ".[.][]". Where: . is the WM8904 driver's version number. . is the WM8904 driver's version number. . is an optional "patch" or "dot" release number (which is not included in the string if it equals "00"). . is an optional release type ("a" for alpha, "b" for beta ? not the entire word spelled out) that is not included if the release is a production version (I.e. Not an alpha or beta).

The String does not contain any spaces. For example, "0.03a" "1.00"

### Preconditions

None.

### Returns

returns a string containing the version of WM8904 driver.

### Remarks

None

## Example

```
int8_t *WM8904string;
WM8904string = DRV_WM8904_VersionStrGet();
```

### C

```
int8_t* DRV_WM8904_VersionStrGet();
```

## DRV\_WM8904\_LRCLK\_Sync Function

```
uint32_t DRV_WM8904_LRCLK_Sync (const DRV_HANDLE handle);
```

### Summary

Synchronize to the start of the I2S LRCLK (left/right clock) signal

### Description

This function waits until low-to high transition of the I2S LRCLK (left/right clock) signal (high-low if Left-Justified format, this is determined by the PLIB). In the case where this signal is generated from a codec or other external source, this allows the caller to synchronize calls to the DMA with the LRCLK signal so the left/right channel association is valid.

### Preconditions

None.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

true if the function was successful, false if a timeout occurred (no transitions seen)

## Remarks

None.

## Example

```
// myWM8904Handle is the handle returned
// by the DRV_WM8904_Open function.

DRV_WM8904_LRCLK_Sync(myWM8904Handle);
```

## C

```
bool DRV_WM8904_LRCLK_Sync(const DRV_HANDLE handle);
```

## Data Types and Constants

### DATA\_LENGTH Type

in bits

## C

```
typedef enum DATA_LENGTH@4 DATA_LENGTH;
```

### DRV\_WM8904\_AUDIO\_DATA\_FORMAT Type

Identifies the Serial Audio data interface format.

## Description

WM8904 Audio data format

This enumeration identifies Serial Audio data interface format.

## C

```
typedef enum DRV_WM8904_AUDIO_DATA_FORMAT@2 DRV_WM8904_AUDIO_DATA_FORMAT;
```

### DRV\_WM8904\_BUFFER\_EVENT Type

Identifies the possible events that can result from a buffer add request.

## Description

WM8904 Driver Events

This enumeration identifies the possible events that can result from a buffer add request caused by the client calling either the [DRV\\_WM8904\\_BufferAddWrite\(\)](#) or the [DRV\\_WM8904\\_BufferAddRead\(\)](#) function.

## Remarks

One of these values is passed in the "event" parameter of the event handling callback function that the client registered with the driver by calling the [DRV\\_WM8904\\_BufferEventHandlerSet](#) function when a buffer transfer request is completed.

**C**

```
typedef enum DRV_WM8904_BUFFER_EVENT@2 DRV_WM8904_BUFFER_EVENT;
```

**DRV\_WM8904\_BUFFER\_EVENT\_HANDLER Type**

Pointer to a WM8904 Driver Buffer Event handler function

**Description**

WM8904 Driver Buffer Event Handler Function

This data type defines the required function signature for the WM8904 driver buffer event handling callback function. A client must register a pointer to a buffer event handling function who's function signature (parameter and return value types) match the types specified by this function pointer in order to receive buffer related event calls back from the driver.

The parameters and return values are described here and a partial example implementation is provided.

**Parameters**

Parameters	Description
event	Identifies the type of event
bufferHandle	Handle identifying the buffer to which the event relates
context	Value identifying the context of the application that registered the event handling function.

**Returns**

None.

**Remarks**

If the event is DRV\_WM8904\_BUFFER\_EVENT\_COMPLETE, this means that the data was transferred successfully.

If the event is DRV\_WM8904\_BUFFER\_EVENT\_ERROR, this means that the data was not transferred successfully. The bufferHandle parameter contains the buffer handle of the buffer that failed. The DRV\_WM8904\_BufferProcessedSizeGet() function can be called to find out how many bytes were processed.

The bufferHandle parameter contains the buffer handle of the buffer that associated with the event.

The context parameter contains a handle to the client context, provided at the time the event handling function was registered using the [DRV\\_WM8904\\_BufferEventHandlerSet](#) function. This context handle value is passed back to the client as the "context" parameter. It can be any value necessary to identify the client context or instance (such as a pointer to the client's data) instance of the client that made the buffer add request.

The buffer handle in bufferHandle expires after this event handler exits. In that the buffer object that was allocated is deallocated by the driver after the event handler exits.

The event handler function executes in the data driver(i2S) peripheral's interrupt context when the driver is configured for interrupt mode operation. It is recommended of the application to not perform process intensive or blocking operations with in this function.

[DRV\\_WM8904\\_BufferAddWrite](#) function can be called in the event handler to add a buffer to the driver queue.

**Example**

```
void APP_MyBufferEventHandler( DRV_WM8904_BUFFER_EVENT event,
                               DRV_WM8904_BUFFER_HANDLE bufferHandle,
                               uintptr_t context )
{
    MY_APP_DATA_STRUCT pAppData = (MY_APP_DATA_STRUCT) context;

    switch(event)
    {
        case DRV_WM8904_BUFFER_EVENT_COMPLETE:
            // Handle the completed buffer.
            break;

        case DRV_WM8904_BUFFER_EVENT_ERROR:
        default:
            // Handle error.
    }
}
```

```

        break;
    }
}

```

**C**

```
typedef void (* DRV_WM8904_BUFFER_EVENT_HANDLER)(DRV_WM8904_BUFFER_EVENT event,
DRV_WM8904_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle);
```

**DRV\_WM8904\_BUFFER\_HANDLE Type**

Handle identifying a write buffer passed to the driver.

**Description**

WM8904 Driver Buffer Handle

A buffer handle value is returned by a call to the [DRV\\_WM8904\\_BufferAddWrite\(\)](#) or [DRV\\_WM8904\\_BufferAddRead\(\)](#) function. This handle is associated with the buffer passed into the function and it allows the application to track the completion of the data from (or into) that buffer.

The buffer handle value returned from the "buffer add" function is returned back to the client by the "event handler callback" function registered with the driver.

The buffer handle assigned to a client request expires when the client has been notified of the completion of the buffer transfer (after event handler function that notifies the client returns) or after the buffer has been retired by the driver if no event handler callback was set.

**Remarks**

None

**C**

```
typedef uintptr_t DRV_WM8904_BUFFER_HANDLE;
```

**DRV\_WM8904\_CHANNEL Type**

Identifies Left/Right Audio channel

**Description**

WM8904 Audio Channel

This enumeration identifies Left/Right Audio channel

**Remarks**

None.

**C**

```
typedef enum DRV_WM8904_CHANNEL@2 DRV_WM8904_CHANNEL;
```

**DRV\_WM8904\_COMMAND\_EVENT\_HANDLER Type**

Pointer to a WM8904 Driver Command Event Handler Function

**Description**

WM8904 Driver Command Event Handler Function

This data type defines the required function signature for the WM8904 driver command event handling callback function.

A command is a control instruction to the WM8904 Codec. Example Mute ON/OFF, Zero Detect Enable/Disable etc.

A client must register a pointer to a command event handling function who's function signature (parameter and return value types) match the types specified by this function pointer in order to receive command related event calls back from the driver.

The parameters and return values are described here and a partial example implementation is provided.

## Parameters

Parameters	Description
context	Value identifying the context of the application that registered the event handling function.

## Returns

None.

## Remarks

The occurrence of this call back means that the last control command was transferred successfully.

The context parameter contains a handle to the client context, provided at the time the event handling function was registered using the [DRV\\_WM8904\\_CommandEventHandlerSet](#) function. This context handle value is passed back to the client as the "context" parameter. It can be any value necessary to identify the client context or instance (such as a pointer to the client's data) instance of the client that made the buffer add request.

The event handler function executes in the control data driver interrupt context. It is recommended of the application to not perform process intensive or blocking operations with in this function.

## Example

```
void APP_WM8904CommandEventHandler( uintptr_t context )
{
    MY_APP_DATA_STRUCT pAppData = (MY_APP_DATA_STRUCT) context;

    // Last Submitted command is completed.
    // Perform further processing here
}
```

## C

```
typedef void (* DRV_WM8904_COMMAND_EVENT_HANDLER)(uintptr_t contextHandle);
```

## DRV\_WM8904\_INIT Type

Defines the data required to initialize or reinitialize the WM8904 driver

## Description

WM8904 Driver Initialization Data

This data type defines the data required to initialize or reinitialize the WM8904 Codec driver.

## Remarks

None.

## C

```
typedef struct DRV_WM8904_INIT@2 DRV_WM8904_INIT;
```

## DRV\_WM8904\_BUFFER\_HANDLE\_INVALID Macro

Definition of an invalid buffer handle.

## Description

WM8904 Driver Invalid Buffer Handle

This is the definition of an invalid buffer handle. An invalid buffer handle is returned by [DRV\\_WM8904\\_BufferAddWrite\(\)](#) and the [DRV\\_WM8904\\_BufferAddRead\(\)](#) function if the buffer add request was not successful.

## Remarks

None.

**C**

```
#define DRV_WM8904_BUFFER_HANDLE_INVALID ((DRV_WM8904_BUFFER_HANDLE)(-1))
```

**DRV\_WM8904\_COUNT Macro**

Number of valid WM8904 driver indices

**Description**

WM8904 Driver Module Count

This constant identifies the maximum number of WM8904 Driver instances that should be defined by the application. Defining more instances than this constant will waste RAM memory space.

This constant can also be used by the application to identify the number of WM8904 instances on this microcontroller.

**Remarks**

This value is part-specific.

**C**

```
#define DRV_WM8904_COUNT
```

**DRV\_WM8904\_INDEX\_0 Macro**

WM8904 driver index definitions

**Description**

Driver WM8904 Module Index

These constants provide WM8904 driver index definition.

**Remarks**

These constants should be used in place of hard-coded numeric literals. These values should be passed into the [DRV\\_WM8904\\_Initialize](#) and [DRV\\_WM8904\\_Open](#) routines to identify the driver instance in use.

**C**

```
#define DRV_WM8904_INDEX_0 0
```

**Files****Files**

Name	Description
<a href="#">drv_wm8904.h</a>	WM8904 Codec Driver Interface header file
<a href="#">drv_wm8904_config_template.h</a>	WM8904 Codec Driver Configuration Template.

**Description**

This section will list only the library's interface header file(s).

**drv\_wm8904.h**

drv\_wm8904.h

**Summary**

WM8904 Codec Driver Interface header file

## Description

WM8904 Codec Driver Interface

The WM8904 Codec device driver interface provides a simple interface to manage the WM8904 16/24/32-Bit Codec that can be interfaced to a Microchip microcontroller. This file provides the public interface definitions for the WM8904 Codec device driver.

### **drv\_wm8904\_config\_template.h**

drv\_wm8904\_config\_template.h

## Summary

WM8904 Codec Driver Configuration Template.

## Description

WM8904 Codec Driver Configuration Template

These file provides the list of all the configurations that can be used with the driver. This file should not be included in the driver.

## AK4954 CODEC Driver Library Help

This topic describes the AK4954 Codec Driver Library.

## Introduction

This topic describes the basic architecture of the AK4954 Codec Driver Library and provides information and examples on its use.

## Description

**Interface Header File:** `drv_AK4954.h`

The interface to the AK4954 Codec Driver library is defined in the `audio/driver/codec/AK4954/drv_AK4954.h` header file. Any C language source (.c) file that uses the AK4954 Codec Driver library should include this header.

### Library Source Files:

The AK4954 Codec Driver library source files are provided in the `audio/driver/codec/AK4954/src` directory. This folder may contain optional files and alternate implementations. Please refer to **Configuring the Library** for instructions on how to select optional features and to **Building the Library** for instructions on how to build the library.

### Example Applications:

This library is used by the following applications:

- `audio/apps/audio_tone`
- `audio/apps/microphone_loopback`

## Using the Library

### Abstraction Model

This library provides a low-level abstraction of the AK4954 Codec Driver Library on the Microchip family microcontrollers with a convenient C language interface. This topic describes how that abstraction is modeled in software and introduces the library's interface.

## Description

The abstraction model shown in the following diagram depicts how the AK4954 Codec Driver is positioned in the MPLAB Harmony

framework. The AK4954 Codec Driver uses the I2C and I2S drivers for control and audio data transfers to the AK4954 module.

### AK4954 Driver Abstraction Model

## Library Overview

Refer to the Driver Library Overview section for information on how the driver operates in a system.

The AK4954 Codec Driver Library provides an API interface to transfer control commands and digital audio data to the serially interfaced AK4954 Codec module. The library interface routines are divided into various sub-sections, which address one of the blocks or the overall operation of the AK4954 Codec Driver Library.

Library Interface Section	Description
System Functions	Provides system module interfaces, device initialization, deinitialization, reinitialization, tasks and status functions.
Client Setup Functions	Provides open and close functions.
Data Transfer Functions	Provides data transfer functions, such as Buffer Read and Write.
Settings Functions	Provides driver specific functions for settings, such as volume control and sampling rate.
Other Functions	Miscellaneous functions, such as getting the driver's version number and syncing to the LRCLK signal.
Data Types and Constants	These data types and constants are required while interacting and setting up the AK4954 Codec Driver Library.

 **Note:** All functions and constants in this section are named with the format DRV\_AK4954\_xxx, where 'xxx' is a function name or constant. These names are redefined in the appropriate configuration's configuration.h file to the format DRV\_CODEC\_xxx using #defines so that code in the application that references the library can be written as generically as possible (e.g., by writing DRV\_CODEC\_Open instead of DRV\_AK4954\_Open etc.). This allows the codec type to be changed in the MHC without having to modify the application's source code.

## How the Library Works

### How the Library Works

The library provides interfaces to support:

- System Functionality
- Client Functionality

## Setup (Initialization)

This topic describes system initialization, implementations, and includes a system access code example.

### Description

#### System Initialization

The system performs the initialization of the device driver with settings that affect only the instance of the device that is being initialized. During system initialization in the system\_init.c file, each instance of the AK4954 module would be initialized with the following configuration settings (either passed dynamically at run time using [DRV\\_AK4954\\_INIT](#) or by using Initialization Overrides) that are supported by the specific AK4954 device hardware:

- Device requested power state: one of the System Module Power States. For specific details please refer to Data Types and Constants in the Library Interface section.
- I2C driver module index. The module index should be same as the one used in initializing the I2C Driver
- I2S driver module index. The module index should be same as the one used in initializing the I2S Driver
- Sampling rate

- Volume
- Audio data format. The audio data format should match with the audio data format settings done in I2S driver initialization
- Determines whether or not the microphone input is enabled

The [DRV\\_AK4954\\_Initialize](#) API returns an object handle of the type SYS\_MODULE\_OBJ. The object handle returned by the Initialize interface would be used by the other system interfaces such as [DRV\\_AK4954\\_Deinitialize](#), [DRV\\_AK4954\\_Status](#) and [DRV\\_I2S\\_Tasks](#)

## Client Access

This topic describes driver initialization and provides a code example.

### Description

For the application to start using an instance of the module, it must call the [DRV\\_AK4954\\_Open](#) function. The [DRV\\_AK4954\\_Open](#) function provides a driver handle to the AK4954 Codec Driver instance for operations. If the driver is deinitialized using the function [DRV\\_AK4954\\_Deinitialize](#), the application must call the [DRV\\_AK4954\\_Open](#) function again to set up the instance of the driver.

For the various options available for IO\_INTENT, please refer to Data Types and Constants in the Library Interface section.

 **Note:** It is necessary to check the status of driver initialization before opening a driver instance. The status of the AK4954 Codec Driver can be known by calling [DRV\\_AK4954\\_Status](#).

### Example:

```
DRV_HANDLE handle;
SYS_STATUS ak4954Status;
ak4954Status Status = DRV\_AK4954\_Status(sysObjects.ak4954Status DevObject);
if (SYS_STATUS_READY == ak4954Status)
{
    // The driver can now be opened.
    appData.ak4954Client.handle = DRV\_AK4954\_Open
    ( DRV\_AK4954\_INDEX\_0, DRV_IO_INTENT_WRITE | DRV_IO_INTENT_EXCLUSIVE);
    if(appData.ak4954Client.handle != DRV_HANDLE_INVALID)
    {
        appData.state = APP_STATE_AK4954_SET_BUFFER_HANDLER;
    }
    else
    {
        SYS_DEBUG(0, "Find out what's wrong \r\n");
    }
}
else
{
    /* AK4954 Driver Is not ready */
}
```

## Client Operations

This topic provides information on client operations.

### Description

Client operations provide the API interface for control command and audio data transfer to the AK4954 Codec.

The following AK4954 Codec specific control command functions are provided:

- [DRV\\_AK4954\\_SamplingRateSet](#)

- [DRV\\_AK4954\\_SamplingRateGet](#)
- [DRV\\_AK4954\\_VolumeSet](#)
- [DRV\\_AK4954\\_VolumeGet](#)
- [DRV\\_AK4954\\_MuteOn](#)
- [DRV\\_AK4954\\_MuteOff](#)

These functions schedule a non-blocking control command transfer operation. These functions submit the control command request to the AK4954 Codec. These functions submit the control command request to I2C Driver transmit queue, the request is processed immediately if it is the first request, or processed when the previous request is complete.

[DRV\\_AK4954\\_BufferAddWrite](#), [DRV\\_AK4954\\_BufferAddRead](#), and [DRV\\_AK4954\\_BufferAddWriteRead](#) are buffered data operation functions. These functions schedule non-blocking audio data transfer operations. These functions add the request to I2S Driver transmit or receive buffer queue depends on the request type, and are executed immediately if it is the first buffer, or executed later when the previous buffer is complete. The driver notifies the client with [DRV\\_AK4954\\_BUFFER\\_EVENT\\_COMPLETE](#), [DRV\\_AK4954\\_BUFFER\\_EVENT\\_ERROR](#), or [DRV\\_AK4954\\_BUFFER\\_EVENT\\_ABORT](#) events.



**Note:** It is not necessary to close and reopen the client between multiple transfers.

## Configuring the Library

The configuration of the I2S Driver Library is based on the file configurations.h, as generated by the MHC.

This header file contains the configuration selection for the I2S Driver Library. Based on the selections made, the I2S Driver Library may support the selected features. These configuration settings will apply to all instances of the I2S Driver Library.

This header can be placed anywhere; however, the path of this header needs to be present in the include search path for a successful build. Refer to the Applications Help section for more details.

## System Configuration

### Macros

	Name	Description
	<a href="#">DRV_AK4954_AUDIO_DATA_FORMAT_MACRO</a>	Specifies the audio data format for the codec.
	<a href="#">DRV_AK4954_AUDIO_SAMPLING_RATE</a>	Specifies the initial baud rate for the codec.
	<a href="#">DRV_AK4954_CLIENTS_NUMBER</a>	Sets up the maximum number of clients that can be connected to any hardware instance.
	<a href="#">DRV_AK4954_ENABLE_MIC_BIAS</a>	Specifies whether to enable the microphone bias.
	<a href="#">DRV_AK4954_I2C_DRIVER_MODULE_INDEX_IDxx</a>	Specifies the instance number of the I2C interface.
	<a href="#">DRV_AK4954_I2S_DRIVER_MODULE_INDEX_IDxx</a>	Specifies the instance number of the I2S interface.
	<a href="#">DRV_AK4954_INSTANCES_NUMBER</a>	Sets up the maximum number of hardware instances that can be supported
	<a href="#">DRV_AK4954_MASTER_MODE</a>	Specifies if codec is in Master or Slave mode.
	<a href="#">DRV_AK4954_MIC_GAIN</a>	Specifies the gain of the microphone (external or line input only)
	<a href="#">DRV_AK4954_VOLUME</a>	Specifies the initial volume level.
	<a href="#">DRV_AK4954_WHICH_MIC_INPUT</a>	Specifies whether to enable the microphone input.

### Description

#### [DRV\\_AK4954\\_AUDIO\\_DATA\\_FORMAT\\_MACRO](#) Macro

Specifies the audio data format for the codec.

## Description

AK4954 Audio Data Format

Sets up the length of each sample plus the format (I2S or left-justified) for the audio.

Valid choices are: "DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_24BIT\_MSB\_SDTO\_24BIT\_LSB\_SDTI"  
"DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_24BIT\_MSB\_SDTO\_16BIT\_LSB\_SDTI"  
"DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_24BIT\_MSB\_SDTO\_24BIT\_MSB\_SDTI"  
"DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_I2S\_16BIT\_24BIT"  
"DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_32BIT\_MSB\_SDTO\_32BIT\_MSB\_SDTI"  
"DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_I2S\_32BIT" where SDTO is input line (ADC) and SDTI is output line (DAC)

## Remarks

If 24-bit audio is needed, it should be sent, left-justified, in a 32-bit format.

## C

```
#define DRV_AK4954_AUDIO_DATA_FORMAT_MACRO
```

## DRV\_AK4954\_AUDIO\_SAMPLING\_RATE Macro

Specifies the initial baud rate for the codec.

## Description

AK4954 Baud Rate

Sets the initial baud rate (sampling rate) for the codec. Typical values are 8000, 16000, 44100, 48000, 88200 and 96000.

## C

```
#define DRV_AK4954_AUDIO_SAMPLING_RATE
```

## DRV\_AK4954\_CLIENTS\_NUMBER Macro

Sets up the maximum number of clients that can be connected to any hardware instance.

## Description

AK4954 Client Count Configuration

Sets up the maximum number of clients that can be connected to any hardware instance. Typically only one client could be connected to one hardware instance. This value represents the total number of clients to be supported across all hardware instances.

## C

```
#define DRV_AK4954_CLIENTS_NUMBER
```

## DRV\_AK4954\_ENABLE\_MIC\_BIAS Macro

Specifies whether to enable the microphone bias.

## Description

AK4954 Microphone Enable

Indicates whether the bias voltage needed for electret microphones should be enabled.

## C

```
#define DRV_AK4954_ENABLE_MIC_BIAS
```

## DRV\_AK4954\_I2C\_DRIVER\_MODULE\_INDEX\_IDXx Macro

Specifies the instance number of the I2C interface.

### Description

AK4954 I2C instance number

Specifies the instance number of the I2C interface being used by the MCU to send commands and receive status to and from the AK4954, enabled.

C

```
#define DRV_AK4954_I2C_DRIVER_MODULE_INDEX_IDXx
```

## DRV\_AK4954\_I2S\_DRIVER\_MODULE\_INDEX\_IDXx Macro

Specifies the instance number of the I2S interface.

### Description

AK4954 I2S instance number

Specifies the instance number of the I2S interface being used by the MCU to send and receive audio data to and from the AK4954, enabled.

C

```
#define DRV_AK4954_I2S_DRIVER_MODULE_INDEX_IDXx
```

## DRV\_AK4954\_INSTANCES\_NUMBER Macro

Sets up the maximum number of hardware instances that can be supported

### Description

AK4954 driver objects configuration

Sets up the maximum number of hardware instances that can be supported. It is recommended that this number be set exactly equal to the number of AK4954 Codec modules that are needed by an application, namely one.

C

```
#define DRV_AK4954_INSTANCES_NUMBER
```

## DRV\_AK4954\_MASTER\_MODE Macro

Specifies if codec is in Master or Slave mode.

### Description

AK4954 Codec Master/Slave Mode

Indicates whether the codec is to be operating in a Master mode (generating word and bit clock as outputs) or Slave mode receiving word and bit clock as inputs).

C

```
#define DRV_AK4954_MASTER_MODE
```

## DRV\_AK4954\_MIC\_GAIN Macro

Specifies the gain of the microphone (external or line input only)

## Description

AK4954 Microphone Gain

Specifies the gain of the microphone (external or line input only), on a scale of 0-31

## C

```
#define DRV_AK4954_MIC_GAIN
```

## DRV\_AK4954\_VOLUME Macro

Specifies the initial volume level.

## Description

AK4954 Volume

Sets the initial volume level, in the range 0-255.

## Remarks

The value is mapped to an internal AK4954 volume level in the range 0-192 using a logarithmic table so the input scale appears linear (128 is half volume).

## C

```
#define DRV_AK4954_VOLUME
```

## DRV\_AK4954\_WHICH\_MIC\_INPUT Macro

Specifies whether to enable the microphone input.

## Description

AK4954 Which Microphone

Indicates which microphone (or line input) is chosen

Valid choices are: "MIC1" (Internal Mic on board) "MIC2" (External Mic Input) "MIC3" (Line Input)

## C

```
#define DRV_AK4954_WHICH_MIC_INPUT
```

## Configuring MHC

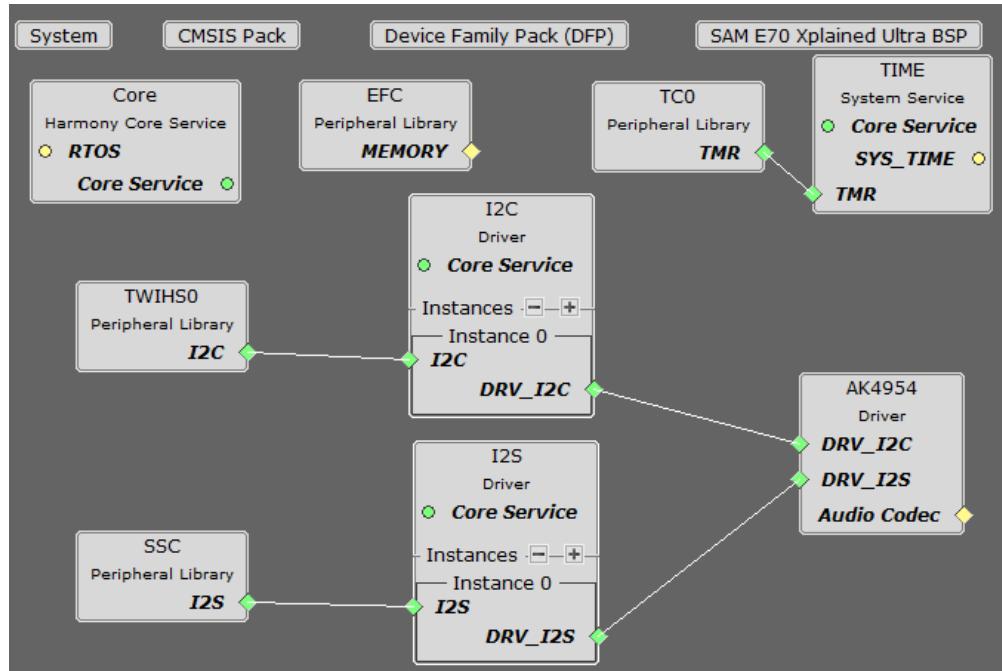
Provides examples on how to configure the MPLAB Harmony Configurator (MHC) for a specific driver.

## Description

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP, and select the appropriate processor (such as ATSAME70Q21B).

In the MHC, under Available Components select the appropriate BSP, such as SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on a codec template such as AK4954. Answer Yes to all questions.

You should end up with a project graph that looks like this, after rearranging the boxes:



Click on the AK4954 Driver component (not AK4954 Codec) and the following menu will be displayed in the Configurations Options:

- **I<sup>2</sup>C Driver Used** will display the driver instance used for the I<sup>2</sup>C interface.
- **I<sup>2</sup>S Driver Used** will display the driver instance used for the I<sup>2</sup>S interface.
- **Usage Mode** indicates whether the AK4954 is a Master (supplies I<sup>2</sup>S clocks) or a Slave (MCU supplies I<sup>2</sup>S clocks).
- **Number of AK4954 Clients** indicates the maximum number of clients that can be connected to the AK4954 Driver.
- **Sampling Rate** indicates the number of samples per second per channel, 8000 to 96,000.
- **Volume** indicates the volume in a linear scale from 0-255.
- **Audio Data Format** is either
  - 24-bit Left Justified (ADC), 24-bit Right-justified(DAC)
  - 24-bit Left Justified (ADC), 16-bit Right-justified(DAC)
  - 24-bit Left Justified (ADC), 24-bit Left-justified(DAC)
  - 24/16-bit I2S
  - 32-bit Left Justified (ADC), 32-bit Left-justified(DAC)
  - 32-bit I2S

It must match the audio protocol and data length set up in either the SSC or I2S PLIB.

- **Microphone/Line Input** selects which microphone or line input is selected, either:
  - Internal Mic (mounted on the AK4954 daughterboard)
  - External Mic Input
  - Line Input

If External Mic input or Line Input is selected, then the following option is provided:

- **Ext Mic Gain in dB range 0(min) to 31(max)**

If External Mic input is selected, then the following option is provided:

- **Enable Microphone Bias** should be checked if using an electret microphone.

You can also bring in the AK4954 Driver by itself, by double clicking AK4954 under Audio->Driver->Codec in the Available Components list. You will then need to add any additional needed components manually and connect them together.

Note that the AK4954 requires the TCx Peripheral Library and TIME System Service in order to perform some of its internal timing sequences.

## Building the Library

This section lists the files that are available in the AK4954 Codec Driver Library.

## Description

This section lists the files that are available in the `src` folder of the AK4954 Codec Driver. It lists which files need to be included in the build based on either a hardware feature present on the board or configuration option selected by the system.

The following three tables list and describe the header (`.h`) and source (`.c`) files that implement this library. The parent folder for these files is `audio/driver/codec/AK4954`.

### Interface File(s)

This table lists and describes the header files that must be included (i.e., using `#include`) by any code that uses this library.

Source File Name	Description
<code>drv_ak4954.h</code>	Header file that exports the driver API.

### Required File(s)



**All of the required files listed in the following table are automatically added into the MPLAB X IDE project by the MHC when the library is selected for use.**

This table lists and describes the source and header files that must always be included in the MPLAB X IDE project to build this library.

Source File Name	Description
<code>/src/drv_ak4954.c</code>	This file contains implementation of the AK4954 Codec Driver.

### Optional File(s)

This table lists and describes the source and header files that may optionally be included if required for the desired implementation.

Source File Name	Description
N/A	No optional files are available for this library.

## Module Dependencies

The AK4954 Codec Driver Library depends on the following modules:

- I2S Driver Library
- I2C Driver Library

## Library Interface

### Client Setup Functions

	Name	Description
≡	<code>DRV_AK4954_Open</code>	Opens the specified AK4954 driver instance and returns a handle to it.
≡	<code>DRV_AK4954_Close</code>	Closes an opened-instance of the AK4954 driver
≡	<code>DRV_AK4954_BufferEventHandlerSet</code>	This function allows a client to identify a buffer event handling function for the driver to call back when queued buffer transfers have finished.
≡	<code>DRV_AK4954_CommandEventHandlerSet</code>	This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

### Data Transfer Functions

	Name	Description
≡	<code>DRV_AK4954_BufferAddRead</code>	Schedule a non-blocking driver read operation.
≡	<code>DRV_AK4954_BufferAddWrite</code>	Schedule a non-blocking driver write operation.
≡	<code>DRV_AK4954_BufferAddReadWrite</code>	Schedule a non-blocking driver write-read operation.

<a href="#">=Ω</a>	<a href="#">DRV_AK4954_ReadQueuePurge</a>	Removes all buffer requests from the read queue.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_WriteQueuePurge</a>	Removes all buffer requests from the write queue.

## Data Types and Constants

	Name	Description
	<a href="#">DRV_AK4954_AUDIO_DATA_FORMAT</a>	Identifies the Serial Audio data interface format.
	<a href="#">DRV_AK4954_BUFFER_EVENT</a>	Identifies the possible events that can result from a buffer add request.
	<a href="#">DRV_AK4954_BUFFER_EVENT_HANDLER</a>	Pointer to a AK4954 Driver Buffer Event handler function
	<a href="#">DRV_AK4954_BUFFER_HANDLE</a>	Handle identifying a write buffer passed to the driver.
	<a href="#">DRV_AK4954_CHANNEL</a>	Identifies Left/Right Audio channel
	<a href="#">DRV_AK4954_COMMAND_EVENT_HANDLER</a>	Pointer to a AK4954 Driver Command Event Handler Function
	<a href="#">DRV_AK4954_DIGITAL_BLOCK_CONTROL</a>	Identifies Bass-Boost Control function
	<a href="#">DRV_AK4954_INIT</a>	Defines the data required to initialize or reinitialize the AK4954 driver
	<a href="#">DRV_AK4954_INT_EXT_MIC</a>	Identifies the Mic input source.
	<a href="#">DRV_AK4954_MIC</a>	This is type <a href="#">DRV_AK4954_MIC</a> .
	<a href="#">DRV_AK4954_MONO_STEREO_MIC</a>	Identifies the Mic input as Mono / Stereo.
	<a href="#">SAMPLE_LENGTH</a>	in bits
	<a href="#">DRV_AK4954_AUDIO_DATA_FORMAT_I2S</a>	for compatibility with old code
	<a href="#">DRV_AK4954_BUFFER_HANDLE_INVALID</a>	Definition of an invalid buffer handle.
	<a href="#">DRV_AK4954_COUNT</a>	Number of valid AK4954 driver indices
	<a href="#">DRV_AK4954_INDEX_0</a>	AK4954 driver index definitions
	<a href="#">DRV_AK4954_INDEX_1</a>	This is macro <a href="#">DRV_AK4954_INDEX_1</a> .
	<a href="#">DRV_AK4954_INDEX_2</a>	This is macro <a href="#">DRV_AK4954_INDEX_2</a> .
	<a href="#">DRV_AK4954_INDEX_3</a>	This is macro <a href="#">DRV_AK4954_INDEX_3</a> .
	<a href="#">DRV_AK4954_INDEX_4</a>	This is macro <a href="#">DRV_AK4954_INDEX_4</a> .
	<a href="#">DRV_AK4954_INDEX_5</a>	This is macro <a href="#">DRV_AK4954_INDEX_5</a> .

## Other Functions

	Name	Description
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_LRCLK_Sync</a>	Synchronize to the start of the I2S LRCLK (left/right clock) signal
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_GetI2SDriver</a>	Get the handle to the I2S driver for this codec instance.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_VersionStrGet</a>	This function returns the version of AK4954 driver in string format.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_VersionGet</a>	This function returns the version of AK4954 driver.

## Settings Functions

	Name	Description
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_MicGainGet</a>	This function gets the microphone gain for the AK4954 Codec.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_MicGainSet</a>	This function sets the microphone gain for the AK4954 CODEC.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_MicMuteOff</a>	Unmutes the AK4954's microphone input.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_MicMuteOn</a>	Mutes the AK4954's microphone input
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_MicSet</a>	This function sets up the codec for the internal or the AK4954 Mic1 or Mic2 input.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_MonoStereoMicSet</a>	This function sets up the codec for the Mono or Stereo microphone mode.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_MuteOff</a>	This function disables AK4954 output for soft mute.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_MuteOn</a>	This function allows AK4954 output for soft mute on.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_IntExtMicSet</a>	This function sets up the codec for the X32 DB internal or the external microphone use.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_SamplingRateGet</a>	This function gets the sampling rate set on the DAC AK4954.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_SamplingRateSet</a>	This function sets the sampling rate of the media stream.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_VolumeGet</a>	This function gets the volume for AK4954 Codec.
<a href="#">=Ω</a>	<a href="#">DRV_AK4954_VolumeSet</a>	This function sets the volume for AK4954 Codec.

## System Interaction Functions

	Name	Description
≡	<a href="#">DRV_AK4954_Initialize</a>	Initializes hardware and data for the instance of the AK4954 Codec module.
≡	<a href="#">DRV_AK4954_EnableInitialization</a>	Enable delayed initialization of the driver.
≡	<a href="#">DRV_AK4954_IsInitializationDelayed</a>	Checks if delayed initialization of the driver has been requested.
≡	<a href="#">DRV_AK4954_Deinitialize</a>	Deinitializes the specified instance of the AK4954 driver module.
≡	<a href="#">DRV_AK4954_Status</a>	Gets the current status of the AK4954 driver module.
≡	<a href="#">DRV_AK4954_Tasks</a>	Maintains the driver's control and data interface state machine.

## Description

### System Interaction Functions

#### DRV\_AK4954\_Initialize Function

```
SYS_MODULE_OBJ DRV_AK4954_Initialize
(
    const SYS_MODULE_INDEX drvIndex,
    const SYS_MODULE_INIT *const init
);
```

## Summary

Initializes hardware and data for the instance of the AK4954 Codec module.

## Description

This routine initializes the AK4954 driver instance for the specified driver index, making it ready for clients to open and use it. The initialization data is specified by the init parameter. The initialization may fail if the number of driver objects allocated are insufficient or if the specified driver instance is already initialized.

## Preconditions

DRV\_I2S\_Initialize must be called before calling this function to initialize the data interface of this Codec driver.  
DRV\_I2C\_Initialize must be called if SPI driver is used for handling the control interface of this Codec driver.

## Parameters

Parameters	Description
drvIndex	Identifier for the driver instance to be initialized
init	Pointer to the data structure containing any data necessary to initialize the hardware. This pointer may be null if no data is required and default initialization is to be used.

## Returns

If successful, returns a valid handle to a driver instance object. Otherwise, it returns SYS\_MODULE\_OBJ\_INVALID.

## Remarks

This routine must be called before any other AK4954 routine is called.

This routine should only be called once during system initialization unless [DRV\\_AK4954\\_Deinitialize](#) is called to deinitialize the driver instance. This routine will NEVER block for hardware access.

## Example

```
DRV_AK4954_INIT
SYS_MODULE_OBJ
init;
objectHandle;
```

```

init->inUse           = true;
init->status          = SYS_STATUS_BUSY;
init->numClients      = 0;
init->i2sDriverModuleIndex = ak4954Init->i2sDriverModuleIndex;
init->i2cDriverModuleIndex = ak4954Init->i2cDriverModuleIndex;
init->samplingRate    = DRV_AK4954_AUDIO_SAMPLING_RATE;
init->audioDataFormat = DRV_AK4954_AUDIO_DATA_FORMAT_MACRO;
for(index=0; index < DRV_AK4954_NUMBER_OF_CHANNELS; index++)
{
    init->volume[index] = ak4954Init->volume;
}
init->isInInterruptContext = false;

init->commandCompleteCallback = (DRV_AK4954_COMMAND_EVENT_HANDLER)0;
init->commandContextData = 0;

init->mclk_multiplier = DRV_AK4954_MCLK_SAMPLE_FREQ_MULTIPLIER;

objectHandle = DRV_AK4954_Initialize(DRV_AK4954_0, (SYS_MODULE_INIT*)init);
if (SYS_MODULE_OBJ_INVALID == objectHandle)
{
    // Handle error
}

```

**C**

```
SYS_MODULE_OBJ DRV_AK4954_Initialize(const SYS_MODULE_INDEX drvIndex, const SYS_MODULE_INIT *  
const init);
```

**DRV\_AK4954\_EnableInitialization Function**

void DRV\_AK4954\_EnableInitialization(SYS\_MODULE\_OBJ object);

**Summary**

Enable delayed initialization of the driver.

**Description**

If the AK4954 codec is sharing a RESET line with another peripheral, such as a Bluetooth module with its own driver, then the codec driver initialization has to be delayed until after the Bluetooth module has toggled its RESET pin. Once this has been accomplished, this function should be called to kick-start the codec driver initialization.

**Preconditions**

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

**Parameters**

Parameters	Description
object	Object handle for the specified driver instance (returned from <a href="#">DRV_AK4954_Initialize</a> )

**Returns**

None.

**Remarks**

This is not needed for audio-only applications without a Bluetooth module.

**C**

```
void DRV_AK4954_EnableInitialization(SYS_MODULE_OBJ object);
```

## DRV\_AK4954\_IsInitializationDelayed Function

```
bool DRV_AK4954_IsInitializationDelayed(SYS_MODULE_OBJ object);
```

### Summary

Checks if delayed initialization of the driver has been requested.

### Description

If the AK4954 codec is sharing a RESET line with another peripheral, such as a Bluetooth module with its own driver, then the codec driver initialization has to be delayed until after the Bluetooth module has toggled its RESET pin. This function returns true if that option has been selected in MHC in the checkbox: "Delay driver initialization (due to shared RESET pin)"

### Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

### Parameters

Parameters	Description
object	Object handle for the specified driver instance (returned from <a href="#">DRV_AK4954_Initialize</a> )

### Returns

true if the delayed initialization option has been enabled

### Remarks

This is not needed for audio-only applications without a Bluetooth module.

### C

```
bool DRV_AK4954_IsInitializationDelayed( SYS_MODULE_OBJ object );
```

## DRV\_AK4954\_Deinitialize Function

```
void DRV_AK4954_Deinitialize( SYS_MODULE_OBJ object)
```

### Summary

Deinitializes the specified instance of the AK4954 driver module.

### Description

Deinitializes the specified instance of the AK4954 driver module, disabling its operation (and any hardware). Invalidates all the internal data.

### Preconditions

Function [DRV\\_AK4954\\_Initialize](#) should have been called before calling this function.

### Parameters

Parameters	Description
object	Driver object handle, returned from the <a href="#">DRV_AK4954_Initialize</a> routine

### Returns

None.

### Remarks

Once the Initialize operation has been called, the De-initialize operation must be called before the Initialize operation can be called again. This routine will NEVER block waiting for hardware.

## Example

```
SYS_MODULE_OBJ      object;      // Returned from DRV_AK4954_Initialize
SYS_STATUS          status;

DRV_AK4954_Deinitialize(object);

status = DRV_AK4954_Status(object);
if (SYS_MODULE_DEINITIALIZED != status)
{
    // Check again later if you need to know
    // when the driver is deinitialized.
}
```

## C

```
void DRV_AK4954_Deinitialize(SYS_MODULE_OBJ object);
```

## DRV\_AK4954\_Status Function

SYS\_STATUS DRV\_AK4954\_Status( SYS\_MODULE\_OBJ object)

### Summary

Gets the current status of the AK4954 driver module.

### Description

This routine provides the current status of the AK4954 driver module.

### Preconditions

Function [DRV\\_AK4954\\_Initialize](#) should have been called before calling this function.

### Parameters

Parameters	Description
object	Driver object handle, returned from the <a href="#">DRV_AK4954_Initialize</a> routine

### Returns

SYS\_STATUS\_DEINITIALIZED - Indicates that the driver has been deinitialized

SYS\_STATUS\_READY - Indicates that any previous module operation for the specified module has completed

SYS\_STATUS\_BUSY - Indicates that a previous module operation for the specified module has not yet completed

SYS\_STATUS\_ERROR - Indicates that the specified module is in an error state

### Remarks

A driver can be opened only when its status is SYS\_STATUS\_READY.

## Example

```
SYS_MODULE_OBJ      object;      // Returned from DRV_AK4954_Initialize
SYS_STATUS          AK4954Status;

AK4954Status = DRV_AK4954_Status(object);
if (SYS_STATUS_READY == AK4954Status)
{
    // This means the driver can be opened using the
    // DRV_AK4954_Open() function.
}
```

## C

```
SYS_STATUS DRV_AK4954_Status(SYS_MODULE_OBJ object);
```

## DRV\_AK4954\_Tasks Function

```
void DRV_AK4954_Tasks(SYS_MODULE_OBJ object);
```

### Summary

Maintains the driver's control and data interface state machine.

### Description

This routine is used to maintain the driver's internal control and data interface state machine and implement its control and data interface implementations. This function should be called from the SYS\_Tasks() function.

### Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

### Parameters

Parameters	Description
object	Object handle for the specified driver instance (returned from <a href="#">DRV_AK4954_Initialize</a> )

### Returns

None.

### Remarks

This routine is normally not called directly by an application. It is called by the system's Tasks routine (SYS\_Tasks).

### Example

```
SYS_MODULE_OBJ          object;      // Returned from DRV_AK4954_Initialize

while (true)
{
    DRV_AK4954_Tasks (object);

    // Do other tasks
}
```

### C

```
void DRV_AK4954_Tasks(SYS_MODULE_OBJ object);
```

## Client Setup Functions

### DRV\_AK4954\_Open Function

```
DRV_HANDLE DRV_AK4954_Open
(
const SYS_MODULE_INDEX drvIndex,
const DRV_IO_INTENT ioIntent
)
```

### Summary

Opens the specified AK4954 driver instance and returns a handle to it.

### Description

This routine opens the specified AK4954 driver instance and provides a handle that must be provided to all other client-level

operations to identify the caller and the instance of the driver. The ioIntent parameter defines how the client interacts with this driver instance.

The DRV\_IO\_INTENT\_BLOCKING and DRV\_IO\_INTENT\_NONBLOCKING ioIntent options are not relevant to this driver. All the data transfer functions of this driver are non blocking.

AK4954 can be opened with DRV\_IO\_INTENT\_WRITE, or DRV\_IO\_INTENT\_READ or DRV\_IO\_INTENT\_WRITEREAD io\_intent option. This decides whether the driver is used for headphone output, or microphone input or both modes simultaneously.

Specifying a DRV\_IO\_INTENT\_EXCLUSIVE will cause the driver to provide exclusive access to this client. The driver cannot be opened by any other client.

## Preconditions

Function [DRV\\_AK4954\\_Initialize](#) must have been called before calling this function.

## Parameters

Parameters	Description
drvIndex	Identifier for the object instance to be opened
ioIntent	Zero or more of the values from the enumeration DRV_IO_INTENT "ORed" together to indicate the intended use of the driver. See function description for details.

## Returns

If successful, the routine returns a valid open-instance handle (a number identifying both the caller and the module instance).

If an error occurs, the return value is DRV\_HANDLE\_INVALID. Error can occur

- if the number of client objects allocated via [DRV\\_AK4954\\_CLIENTS\\_NUMBER](#) is insufficient.
- if the client is trying to open the driver but driver has been opened exclusively by another client.
- if the driver hardware instance being opened is not initialized or is invalid.
- if the ioIntent options passed are not relevant to this driver.

## Remarks

The handle returned is valid until the [DRV\\_AK4954\\_Close](#) routine is called. This routine will NEVER block waiting for hardware. If the requested intent flags are not supported, the routine will return DRV\_HANDLE\_INVALID. This function is thread safe in a RTOS application. It should not be called in an ISR.

## Example

```
DRV_HANDLE handle;

handle = DRV_AK4954_Open(DRV_AK4954_INDEX_0, DRV_IO_INTENT_WRITEREAD | DRV_IO_INTENT_EXCLUSIVE);
if (DRV_HANDLE_INVALID == handle)
{
    // Unable to open the driver
    // May be the driver is not initialized or the initialization
    // is not complete.
}
```

## C

```
DRV_HANDLE DRV_AK4954_Open(const SYS_MODULE_INDEX iDriver, const DRV_IO_INTENT ioIntent);
```

## DRV\_AK4954\_Close Function

```
void DRV_AK4954_Close( DRV_Handle handle )
```

## Summary

Closes an opened-instance of the AK4954 driver

## Description

This routine closes an opened-instance of the AK4954 driver, invalidating the handle. Any buffers in the driver queue that were submitted by this client will be removed. After calling this routine, the handle passed in "handle" must not be used with any of the remaining driver routines. A new handle must be obtained by calling [DRV\\_AK4954\\_Open](#) before the caller may use the driver

again

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

Usually there is no need for the driver client to verify that the Close operation has completed. The driver will abort any ongoing operations when this routine is called.

## Example

```
DRV_HANDLE handle; // Returned from DRV_AK4954_Open

DRV_AK4954_Close(handle);

C

void DRV_AK4954_Close(const DRV_HANDLE handle);
```

## DRV\_AK4954\_BufferEventHandlerSet Function

```
void DRV_AK4954_BufferEventHandlerSet
(
    DRV_HANDLE handle,
    const     DRV_AK4954_BUFFER_EVENT_HANDLER eventHandler,
    const uintptr_t contextHandle
)
```

## Summary

This function allows a client to identify a buffer event handling function for the driver to call back when queued buffer transfers have finished.

## Description

This function allows a client to identify a buffer event handling function for the driver to call back when queued buffer transfers have finished. When a client calls [DRV\\_AK4954\\_BufferAddRead](#) function, it is provided with a handle identifying the buffer that was added to the driver's buffer queue. The driver will pass this handle back to the client by calling "eventHandler" function when the buffer transfer has completed.

The event handler should be set before the client performs any "buffer add" operations that could generate events. The event handler once set, persists until the client closes the driver or sets another event handler (which could be a "NULL" pointer to indicate no callback).

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
eventHandler	Pointer to the event handler function.

context	The value of parameter will be passed back to the client unchanged, when the eventHandler function is called. It can be used to identify any client specific data object that identifies the instance of the client module (for example, it may be a pointer to the client module's state structure).
---------	---

## Returns

None.

## Remarks

If the client does not want to be notified when the queued buffer transfer has completed, it does not need to register a callback.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_AK4954_BUFFER_HANDLE bufferHandle;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

// Client registers an event handler with driver

DRV_AK4954_BufferEventHandlerSet(myAK4954Handle,
                                 APP_AK4954BufferEventHandler, (uintptr_t)&myAppObj);

DRV_AK4954_BufferAddRead(myAK4954handle, &bufferHandle
                         myBuffer, MY_BUFFER_SIZE);

if(DRV_AK4954_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void APP_AK4954BufferEventHandler(DRV_AK4954_BUFFER_EVENT event,
                                    DRV_AK4954_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_AK4954_BUFFER_EVENT_COMPLETE:

            // This means the data was transferred.
            break;

        case DRV_AK4954_BUFFER_EVENT_ERROR:

            // Error handling here.
            break;

        default:
            break;
    }
}

void DRV_AK4954_BufferEventHandlerSet(DRV_HANDLE handle, const DRV_AK4954_BUFFER_EVENT_HANDLER
                                         eventHandler, const uintptr_t contextHandle);

```

## C

```

void DRV_AK4954_BufferEventHandlerSet(DRV_HANDLE handle, const DRV_AK4954_BUFFER_EVENT_HANDLER
                                         eventHandler, const uintptr_t contextHandle);

```

## DRV\_AK4954\_CommandEventHandlerSet Function

```
void DRV_AK4954_CommandEventHandlerSet
(
    DRV_HANDLE handle,
    const DRV_AK4954_COMMAND_EVENT_HANDLER eventHandler,
    const uintptr_t contextHandle
)
```

### Summary

This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

### Description

This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

When a client calls [DRV\\_AK4954\\_BufferAddWrite](#) function, it is provided with a handle identifying the buffer that was added to the driver's buffer queue. The driver will pass this handle back to the client by calling "eventHandler" function when the buffer transfer has completed.

The event handler should be set before the client performs any "AK4954 CODEC Specific Client Routines" operations that could generate events. The event handler once set, persists until the client closes the driver or sets another event handler (which could be a "NULL" pointer to indicate no callback).

### Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

### Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
eventHandler	Pointer to the event handler function.
context	The value of parameter will be passed back to the client unchanged, when the eventHandler function is called. It can be used to identify any client specific data object that identifies the instance of the client module (for example, it may be a pointer to the client module's state structure).

### Returns

None.

### Remarks

If the client does not want to be notified when the command has completed, it does not need to register a callback.

### Example

```
MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_AK4954_BUFFER_HANDLE bufferHandle;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

// Client registers an event handler with driver

DRV_AK4954_CommandEventHandlerSet(myAK4954Handle,
                                    APP_AK4954CommandEventHandler, (uintptr_t)&myAppObj);

DRV_AK4954_DeEmphasisFilterSet(myAK4954Handle, DRV_AK4954_DEEMPHASIS_FILTER_44_1KHZ)
```

```

// Event is received when
// the buffer is processed.

void APP_AK4954CommandEventHandler(uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        // Last Submitted command is completed.
        // Perform further processing here
    }
}

```

**C**

```

void DRV_AK4954_CommandEventHandlerSet(DRV_HANDLE handle, const
DRV_AK4954_COMMAND_EVENT_HANDLER eventHandler, const uintptr_t contextHandle);

```

**Data Transfer Functions****DRV\_AK4954\_BufferAddRead Function**

```

void DRV_AK4954_BufferAddRead
(
const DRV_HANDLE handle,
DRV_AK4954_BUFFER_HANDLE *bufferHandle,
void *buffer, size_t size
)

```

**Summary**

Schedule a non-blocking driver read operation.

**Description**

This function schedules a non-blocking read operation. The function returns with a valid buffer handle in the bufferHandle argument if the read request was scheduled successfully. The function adds the request to the hardware instance receive queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns [DRV\\_AK4954\\_BUFFER\\_HANDLE\\_INVALID](#)

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the buffer size is 0.
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a [DRV\\_AK4954\\_BUFFER\\_EVENT\\_COMPLETE](#) event if the buffer was processed successfully or [DRV\\_AK4954\\_BUFFER\\_EVENT\\_ERROR](#) event if the buffer was not processed successfully.

**Preconditions**

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 device instance and the [DRV\\_AK4954\\_Status](#) must have returned [SYS\\_STATUS\\_READY](#).

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

[DRV\\_IO\\_INTENT\\_READ](#) must have been specified in the [DRV\\_AK4954\\_Open](#) call.

## Parameters

Parameters	Description
handle	Handle of the AK4954 instance as return by the <a href="#">DRV_AK4954_Open</a> function.
buffer	Data to be transmitted.
size	Buffer size in bytes.
bufferHandle	Pointer to an argument that will contain the return buffer handle.

## Returns

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_AK4954\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

## Remarks

This function is thread safe in a RTOS application. It can be called from within the AK4954 Driver Buffer Event Handler that is registered by this client. It should not be called in the event handler associated with another AK4954 driver instance. It should not otherwise be called directly in an ISR.

## C

```
void DRV_AK4954_BufferAddRead(const DRV_HANDLE handle, DRV_AK4954_BUFFER_HANDLE * bufferHandle,
void * buffer, size_t size);
```

## DRV\_AK4954\_BufferAddWrite Function

```
void DRV_AK4954_BufferAddWrite
(
const DRV_HANDLE handle,
DRV_AK4954_BUFFER_HANDLE *bufferHandle,
void *buffer, size_t size
)
```

## Summary

Schedule a non-blocking driver write operation.

## Description

This function schedules a non-blocking write operation. The function returns with a valid buffer handle in the bufferHandle argument if the write request was scheduled successfully. The function adds the request to the hardware instance transmit queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns [DRV\\_AK4954\\_BUFFER\\_HANDLE\\_INVALID](#)

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the buffer size is 0.
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a [DRV\\_AK4954\\_BUFFER\\_EVENT\\_COMPLETE](#) event if the buffer was processed successfully or [DRV\\_AK4954\\_BUFFER\\_EVENT\\_ERROR](#) event if the buffer was not processed successfully.

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 device instance and the [DRV\\_AK4954\\_Status](#) must have returned [SYS\\_STATUS\\_READY](#).

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

[DRV\\_IO\\_INTENT\\_WRITE](#) must have been specified in the [DRV\\_AK4954\\_Open](#) call.

## Parameters

Parameters	Description
handle	Handle of the AK4954 instance as return by the <a href="#">DRV_AK4954_Open</a> function.
buffer	Data to be transmitted.
size	Buffer size in bytes.
bufferHandle	Pointer to an argument that will contain the return buffer handle.

## Returns

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_AK4954\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

## Remarks

This function is thread safe in a RTOS application. It can be called from within the AK4954 Driver Buffer Event Handler that is registered by this client. It should not be called in the event handler associated with another AK4954 driver instance. It should not otherwise be called directly in an ISR.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_AK4954_BUFFER_HANDLE bufferHandle;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

// Client registers an event handler with driver

DRV_AK4954_BufferEventHandlerSet(myAK4954Handle,
                                 APP_AK4954BufferEventHandler, (uintptr_t)&myAppObj);

DRV_AK4954_BufferAddWrite(myAK4954Handle, &bufferHandle
                           myBuffer, MY_BUFFER_SIZE);

if(DRV_AK4954_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void APP_AK4954BufferEventHandler(DRV_AK4954_BUFFER_EVENT event,
                                    DRV_AK4954_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_AK4954_BUFFER_EVENT_COMPLETE:

            // This means the data was transferred.
            break;

        case DRV_AK4954_BUFFER_EVENT_ERROR:

            // Error handling here.
            break;

        default:
            break;
    }
}

```

**C**

```
void DRV_AK4954_BufferAddWrite(const DRV_HANDLE handle, DRV_AK4954_BUFFER_HANDLE *bufferHandle, void * buffer, size_t size);
```

**DRV\_AK4954\_BufferAddWriteRead Function**

```
void DRV_AK4954_BufferAddWriteRead
(
    const DRV_HANDLE handle,
    DRV_AK4954_BUFFER_HANDLE *bufferHandle,
    void *transmitBuffer,
    void *receiveBuffer,
    size_t size
)
```

**Summary**

Schedule a non-blocking driver write-read operation.

**Description**

This function schedules a non-blocking write-read operation. The function returns with a valid buffer handle in the bufferHandle argument if the write-read request was scheduled successfully. The function adds the request to the hardware instance queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns DRV\_AK4954\_BUFFER\_EVENT\_COMPLETE:

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the client opened the driver for read only or write only
- if the buffer size is 0
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a DRV\_AK4954\_BUFFER\_EVENT\_COMPLETE event if the buffer was processed successfully or DRV\_AK4954\_BUFFER\_EVENT\_ERROR event if the buffer was not processed successfully.

**Preconditions**

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 device instance and the [DRV\\_AK4954\\_Status](#) must have returned SYS\_STATUS\_READY.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

[DRV\\_IO\\_INTENT\\_READWRITE](#) must have been specified in the [DRV\\_AK4954\\_Open](#) call.

**Parameters**

Parameters	Description
handle	Handle of the AK4954 instance as returned by the <a href="#">DRV_AK4954_Open</a> function
bufferHandle	Pointer to an argument that will contain the return buffer handle
transmitBuffer	The buffer where the transmit data will be stored
receiveBuffer	The buffer where the received data will be stored
size	Buffer size in bytes

**Returns**

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_AK4954\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

**Remarks**

This function is thread safe in a RTOS application. It can be called from within the AK4954 Driver Buffer Event Handler that is registered by this client. It should not be called in the event handler associated with another AK4954 driver instance. It should not

otherwise be called directly in an ISR.

This function is useful when there is valid read expected for every AK4954 write. The transmit and receive size must be same.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybufferTx[MY_BUFFER_SIZE];
uint8_t mybufferRx[MY_BUFFER_SIZE];
DRV_AK4954_BUFFER_HANDLE bufferHandle;

// myak4954Handle is the handle returned
// by the DRV_AK4954_Open function.

// Client registers an event handler with driver

DRV_AK4954_BufferEventHandlerSet(myak4954Handle,
                                 APP_AK4954BufferEventHandler, (uintptr_t)&myAppObj);

DRV_AK4954_BufferAddWriteRead(myak4954Handle, &bufferHandle,
                               mybufferTx, mybufferRx, MY_BUFFER_SIZE);

if(DRV_AK4954_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void APP_AK4954BufferEventHandler(DRV_AK4954_BUFFER_EVENT event,
                                    DRV_AK4954_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_AK4954_BUFFER_EVENT_COMPLETE:

            // This means the data was transferred.
            break;

        case DRV_AK4954_BUFFER_EVENT_ERROR:

            // Error handling here.
            break;

        default:
            break;
    }
}

```

## C

```

void DRV_AK4954_BufferAddWriteRead(const DRV_HANDLE handle, DRV_AK4954_BUFFER_HANDLE *
bufferHandle, void * transmitBuffer, void * receiveBuffer, size_t size);

```

## DRV\_AK4954\_ReadQueuePurge Function

```
bool DRV_AK4954_ReadQueuePurge( const DRV_HANDLE handle )
```

### Summary

Removes all buffer requests from the read queue.

### Description

This function removes all the buffer requests from the read queue. The client can use this function to purge the queue on timeout

or to remove unwanted stalled buffer requests or in any other use case.

## Preconditions

`DRV_I2S_Open` must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	Handle of the communication channel as returned by the <code>DRV_AK4954_Open</code> function.

## Returns

True - Read queue purge is successful. False - Read queue purge has failed.

## Remarks

This function is thread safe when used in an RTOS environment. Avoid this function call from within the callback.

## Example

```
// myCodecHandle is the handle returned by the DRV_AK4954_Open function.
// Use DRV_AK4954_BufferAddRead to queue read requests

// Application timeout function, where remove queued buffers.
void APP_TimeOut(void)
{
    if(false == DRV_AK4954_ReadQueuePurge(myCodecHandle))
    {
        //Couldn't purge the read queue, try again.
    }
    else
    {
        //Queue purge successful.
    }
}
```

## C

```
bool DRV_AK4954_ReadQueuePurge(const DRV_HANDLE handle);
```

## DRV\_AK4954\_WriteQueuePurge Function

```
bool DRV_AK4954_WriteQueuePurge( const DRV_HANDLE handle )
```

## Summary

Removes all buffer requests from the write queue.

## Description

This function removes all the buffer requests from the write queue. The client can use this function to purge the queue on timeout or to remove unwanted stalled buffer requests or in any other use case.

## Preconditions

`DRV_AK4954_Open` must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	Handle of the communication channel as returned by the <code>DRV_AK4954_Open</code> function.

## Returns

True - Write queue purge is successful. False - Write queue purge has failed.

## Remarks

This function is thread safe when used in an RTOS environment. Avoid this function call from within the callback.

## Example

```
// myCodecHandle is the handle returned by the DRV_AK4954_Open function.
// Use DRV_AK4954_BufferAddWrite to queue write requests

// Application timeout function, where remove queued buffers.
void APP_TimeOut(void)
{
    if(false == DRV_AK4954_WriteQueuePurge(myCodecHandle))
    {
        //Couldn't purge the write queue, try again.
    }
    else
    {
        //Queue purge successful.
    }
}
```

## C

```
bool DRV_AK4954_WriteQueuePurge(const DRV_HANDLE handle);
```

## Settings Functions

### DRV\_AK4954\_MicGainGet Function

```
uint8_t DRV_AK4954_MicGainGet(DRV_HANDLE handle)
```

## Summary

This function gets the microphone gain for the AK4954 Codec.

## Description

This functions gets the current microphone gain programmed to the Codec AK4954.

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

Microphone gain, in range 0-31.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;
uint8_t gain;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.
```

```
gain = DRV_AK4954_MicGainGet(myAK4954Handle);
```

**C**

```
uint8_t DRV_AK4954_MicGainGet(DRV_HANDLE handle);
```

**DRV\_AK4954\_MicGainSet Function**

```
void DRV_AK4954_MicGainSet(DRV_HANDLE handle, uint8_t gain)
```

**Summary**

This function sets the microphone gain for the AK4954 CODEC.

**Description**

This functions sets the microphone gain value from 0-31 which can range from -1.5 to 28.3 dB

**Preconditions**

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
gain	Gain value, in range 0-31

**Returns**

None.

```
// myAppObj is an application specific object.  
MY_APP_OBJ myAppObj;
```

```
// myAK4954Handle is the handle returned  
// by the DRV_AK4954_Open function.
```

```
DRV_AK4954_MicGainSet(myAK4954Handle, 15); //AK4954 mic gain set to 15
```

**Remarks**

None.

**C**

```
void DRV_AK4954_MicGainSet(DRV_HANDLE handle, uint8_t gain);
```

**DRV\_AK4954\_MicMuteOff Function**

```
void DRV_AK4954_MicMuteOff(DRV_HANDLE handle)
```

**Summary**

Umutes th AK4954's microphone input.

**Description**

This function unmutes the AK4954's microphone input.

**Preconditions**

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

DRV_AK4954_MicMuteOff(myAK4954Handle); //AK4954 microphone unmuted
```

## C

```
void DRV_AK4954_MicMuteOff(DRV_HANDLE handle);
```

## DRV\_AK4954\_MicMuteOn Function

```
void DRV_AK4954_MicMuteOn(DRV_HANDLE handle);
```

## Summary

Mutes the AK4954's microphone input

## Description

This function mutes the AK4954's microphone input

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

DRV_AK4954_MicMuteOn(myAK4954Handle); //AK4954 microphone muted
```

## C

```
void DRV_AK4954_MicMuteOn(DRV_HANDLE handle);
```

## DRV\_AK4954\_MicSet Function

```
void DRV_AK4954_IntMic12Set
```

### Summary

This function sets up the codec for the internal or the AK4954 Mic1 or Mic2 input.

### Description

This function sets up the codec.

### Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

### Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
micInput	Internal vs External mic input

### Returns

None

### Remarks

None.

### C

```
void DRV_AK4954_MicSet(DRV_HANDLE handle, DRV_AK4954_MIC micInput);
```

## DRV\_AK4954\_MonoStereoMicSet Function

```
void DRV_AK4954_MonoStereoMicSet(DRV_HANDLE handle);
```

### Summary

This function sets up the codec for the Mono or Stereo microphone mode.

### Description

This function sets up the codec for the Mono or Stereo microphone mode.

### Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

### Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

### Returns

None

### Remarks

None.

### C

```
void DRV_AK4954_MonoStereoMicSet(DRV_HANDLE handle, DRV_AK4954_MONO_STEREO_MIC mono_stereo_mic);
```

**DRV\_AK4954\_MuteOff Function**

```
void DRV_AK4954_MuteOff(DRV_HANDLE handle)
```

**Summary**

This function disables AK4954 output for soft mute.

**Description**

This function disables AK4954 output for soft mute.

**Preconditions**

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

**Returns**

None.

**Remarks**

None.

**Example**

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_BUFFER_HANDLE bufferHandle;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

DRV_AK4954_MuteOff(myAK4954Handle); //AK4954 output soft mute disabled
```

**C**

```
void DRV_AK4954_MuteOff(DRV_HANDLE handle);
```

**DRV\_AK4954\_MuteOn Function**

```
void DRV_AK4954_MuteOn(DRV_HANDLE handle);
```

**Summary**

This function allows AK4954 output for soft mute on.

**Description**

This function Enables AK4954 output for soft mute.

**Preconditions**

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_BUFFER_HANDLE bufferHandle;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

DRV_AK4954_MuteOn(myAK4954Handle); //AK4954 output soft muted
```

## C

```
void DRV_AK4954_MuteOn(DRV_HANDLE handle);
```

## DRV\_AK4954\_IntExtMicSet Function

void DRV\_AK4954\_IntExtMicSet

## Summary

This function sets up the codec for the X32 DB internal or the external microphone use.

## Description

This function sets up the codec for the internal or the external microphone use.

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
micInput	Internal vs External mic input

## Returns

None

## Remarks

None.

## C

```
void DRV_AK4954_IntExtMicSet(DRV_HANDLE handle, DRV_AK4954_INT_EXT_MIC micInput);
```

## DRV\_AK4954\_SamplingRateGet Function

```
uint32_t DRV_AK4954_SamplingRateGet(DRV_HANDLE handle)
```

### Summary

This function gets the sampling rate set on the DAC AK4954.

### Description

This function gets the sampling rate set on the DAC AK4954.

### Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

### Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

### Returns

None.

### Remarks

None.

### Example

```
uint32_t baudRate;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

baudRate = DRV_AK4954_SamplingRateGet(myAK4954Handle);
```

### C

```
uint32_t DRV_AK4954_SamplingRateGet(DRV_HANDLE handle);
```

## DRV\_AK4954\_SamplingRateSet Function

```
void DRV_AK4954_SamplingRateSet(DRV_HANDLE handle, uint32_t samplingRate)
```

### Summary

This function sets the sampling rate of the media stream.

### Description

This function sets the media sampling rate for the client handle.

### Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

### Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

DRV_AK4954_SamplingRateSet(myAK4954Handle, 48000); //Sets 48000 media sampling rate
```

## C

```
void DRV_AK4954_SamplingRateSet(DRV_HANDLE handle, uint32_t samplingRate);
```

## DRV\_AK4954\_VolumeGet Function

```
uint8_t DRV_AK4954_VolumeGet(DRV_HANDLE handle, DRV_AK4954_CHANNEL chan)
```

## Summary

This function gets the volume for AK4954 Codec.

## Description

This functions gets the current volume programmed to the CODEC AK4954.

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
chan	Audio channel volume to be set

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;
uint8_t volume;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

volume = DRV_AK4954_VolumeGet(myAK4954Handle,DRV_AK4954_CHANNEL_LEFT);
```

## C

```
uint8_t DRV_AK4954_VolumeGet(DRV_HANDLE handle, DRV_AK4954_CHANNEL chan);
```

## DRV\_AK4954\_VolumeSet Function

```
void DRV_AK4954_VolumeSet(DRV_HANDLE handle, DRV_AK4954_CHANNEL channel, uint8_t volume);
```

## Summary

This function sets the volume for AK4954 Codec.

## Description

This functions sets the volume value from 0-255. The codec has DAC value to volume range mapping as :- 00 H : +12dB FF H : -115dB In order to make the volume value to dB mapping monotonically increasing from 00 to FF, re-mapping is introduced which reverses the volume value to dB mapping as well as normalizes the volume range to a more audible dB range. The current driver implementation assumes that all dB values under -60 dB are inaudible to the human ear. Re-Mapped values 00 H : -60 dB FF H : +12 dB

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
chan	Audio channel volume to be set
volume	volume value specified in the range 0-255 (0x00 to 0xFF)

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_BUFFER_HANDLE bufferHandle;

// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.

DRV_AK4954_VolumeSet(myAK4954Handle, DRV_AK4954_CHANNEL_LEFT, 120);

C

void DRV_AK4954_VolumeSet(DRV_HANDLE handle, DRV_AK4954_CHANNEL channel, uint8_t volume);
```

## Other Functions

### DRV\_AK4954\_LRCLK\_Sync Function

```
uint32_t DRV_AK4954_LRCLK_Sync (const DRV_HANDLE handle);
```

## Summary

Synchronize to the start of the I2S LRCLK (left/right clock) signal

## Description

This function waits until low-to high transition of the I2S LRCLK (left/right clock) signal (high-low if Left-Justified format, this is determined by the PLIB). In the case where this signal is generated from a codec or other external source, this allows the caller to

synchronize calls to the DMA with the LRCLK signal so the left/right channel association is valid.

## Preconditions

None.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

true if the function was successful, false if a timeout occurred (no transitions seen)

## Remarks

None.

## Example

```
// myAK4954Handle is the handle returned
// by the DRV_AK4954_Open function.
```

```
DRV_AK4954_LRCLK_Sync(myAK4954Handle);
```

## C

```
bool DRV_AK4954_LRCLK_Sync(const DRV_HANDLE handle);
```

## DRV\_AK4954\_GetI2SDriver Function

DRV\_HANDLE DRV\_AK4954\_GetI2SDriver(DRV\_HANDLE codecHandle)

## Summary

Get the handle to the I2S driver for this codec instance.

## Description

Returns the appropriate handle to the I2S based on the iolent member of the codec object.

## Preconditions

The [DRV\\_AK4954\\_Initialize](#) routine must have been called for the specified AK4954 driver instance.

[DRV\\_AK4954\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

- A handle to the I2S driver for this codec instance

## Remarks

This allows the caller to directly access portions of the I2S driver that might not be available via the codec API.

## C

```
DRV_HANDLE DRV_AK4954_GetI2SDriver(DRV_HANDLE codecHandle);
```

## DRV\_AK4954\_VersionStrGet Function

```
int8_t* DRV_AK4954_VersionStrGet(void)
```

## Summary

This function returns the version of AK4954 driver in string format.

## Description

The DRV\_AK4954\_VersionStrGet function returns a string in the format: "[.][]]" Where: is the AK4954 driver's version number. is the AK4954 driver's version number. is an optional "patch" or "dot" release number (which is not included in the string if it equals "00"). is an optional release type ("a" for alpha, "b" for beta ? not the entire word spelled out) that is not included if the release is a production version (I.e. Not an alpha or beta).

The String does not contain any spaces.

## Preconditions

None.

## Returns

returns a string containing the version of AK4954 driver.

## Remarks

None.

## Example 1

"0.03a" "1.00"

## Example 2

```
int8_t *AK4954string;
AK4954string = DRV_AK4954_VersionStrGet();
```

## C

```
int8_t* DRV_AK4954_VersionStrGet();
```

## DRV\_AK4954\_VersionGet Function

```
uint32_t DRV_AK4954_VersionGet( void )
```

## Summary

This function returns the version of AK4954 driver.

## Description

The version number returned from the DRV\_AK4954\_VersionGet function is an unsigned integer in the following decimal format. \* 10000 + \* 100 + Where the numbers are represented in decimal and the meaning is the same as above. Note that there is no numerical representation of release type.

## Preconditions

None.

## Returns

returns the version of AK4954 driver.

## Remarks

None.

## Example 1

For version "0.03a", return: 0 \* 10000 + 3 \* 100 + 0 For version "1.00", return: 1 \* 100000 + 0 \* 100 + 0

## Example 2

```
uint32_t AK4954version;
AK4954version = DRV_AK4954_VersionGet();
```

**C**

```
uint32_t DRV_AK4954_VersionGet();
```

**Data Types and Constants****DRV\_AK4954\_AUDIO\_DATA\_FORMAT Type**

Identifies the Serial Audio data interface format.

**Description**

AK4954 Audio data format

This enumeration identifies Serial Audio data interface format.

**C**

```
typedef enum DRV_AK4954_AUDIO_DATA_FORMAT@1 DRV_AK4954_AUDIO_DATA_FORMAT;
```

**DRV\_AK4954\_BUFFER\_EVENT Type**

Identifies the possible events that can result from a buffer add request.

**Description**

AK4954 Driver Events

This enumeration identifies the possible events that can result from a buffer add request caused by the client calling either the [DRV\\_AK4954\\_BufferAddWrite\(\)](#) or the [DRV\\_AK4954\\_BufferAddRead\(\)](#) function.

**Remarks**

One of these values is passed in the "event" parameter of the event handling callback function that the client registered with the driver by calling the [DRV\\_AK4954\\_BufferEventHandlerSet](#) function when a buffer transfer request is completed.

**C**

```
typedef enum DRV_AK4954_BUFFER_EVENT@1 DRV_AK4954_BUFFER_EVENT;
```

**DRV\_AK4954\_BUFFER\_EVENT\_HANDLER Type**

Pointer to a AK4954 Driver Buffer Event handler function

**Description**

AK4954 Driver Buffer Event Handler Function

This data type defines the required function signature for the AK4954 driver buffer event handling callback function. A client must register a pointer to a buffer event handling function who's function signature (parameter and return value types) match the types specified by this function pointer in order to receive buffer related event calls back from the driver.

The parameters and return values are described here and a partial example implementation is provided.

**Parameters**

Parameters	Description
event	Identifies the type of event
bufferHandle	Handle identifying the buffer to which the event relates
context	Value identifying the context of the application that registered the event handling function.

## Returns

None.

## Remarks

If the event is DRV\_AK4954\_BUFFER\_EVENT\_COMPLETE, this means that the data was transferred successfully.

If the event is DRV\_AK4954\_BUFFER\_EVENT\_ERROR, this means that the data was not transferred successfully. The bufferHandle parameter contains the buffer handle of the buffer that failed. The DRV\_AK4954\_BufferProcessedSizeGet() function can be called to find out how many bytes were processed.

The bufferHandle parameter contains the buffer handle of the buffer that associated with the event.

The context parameter contains a handle to the client context, provided at the time the event handling function was registered using the [DRV\\_AK4954\\_BufferEventHandlerSet](#) function. This context handle value is passed back to the client as the "context" parameter. It can be any value necessary to identify the client context or instance (such as a pointer to the client's data) instance of the client that made the buffer add request.

The buffer handle in bufferHandle expires after this event handler exits. In that the buffer object that was allocated is deallocated by the driver after the event handler exits.

The event handler function executes in the data driver(i2S) peripheral's interrupt context when the driver is configured for interrupt mode operation. It is recommended of the application to not perform process intensive or blocking operations with in this function.

[DRV\\_AK4954\\_BufferAddWrite](#) function can be called in the event handler to add a buffer to the driver queue.

## Example

```
void APP_MyBufferEventHandler( DRV_AK4954_BUFFER_EVENT event,
                               DRV_AK4954_BUFFER_HANDLE bufferHandle,
                               uintptr_t context )
{
    MY_APP_DATA_STRUCT pAppData = (MY_APP_DATA_STRUCT) context;

    switch(event)
    {
        case DRV_AK4954_BUFFER_EVENT_COMPLETE:
            // Handle the completed buffer.
            break;

        case DRV_AK4954_BUFFER_EVENT_ERROR:
        default:
            // Handle error.
            break;
    }
}
```

## C

```
typedef void (* DRV_AK4954_BUFFER_EVENT_HANDLER)(DRV_AK4954_BUFFER_EVENT event,
DRV_AK4954_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle);
```

## DRV\_AK4954\_BUFFER\_HANDLE Type

Handle identifying a write buffer passed to the driver.

## Description

AK4954 Driver Buffer Handle

A buffer handle value is returned by a call to the [DRV\\_AK4954\\_BufferAddWrite\(\)](#) or [DRV\\_AK4954\\_BufferAddRead\(\)](#) function. This handle is associated with the buffer passed into the function and it allows the application to track the completion of the data from (or into) that buffer.

The buffer handle value returned from the "buffer add" function is returned back to the client by the "event handler callback" function registered with the driver.

The buffer handle assigned to a client request expires when the client has been notified of the completion of the buffer transfer (after event handler function that notifies the client returns) or after the buffer has been retired by the driver if no event handler callback was set.

## Remarks

None

## C

```
typedef uintptr_t DRV_AK4954_BUFFER_HANDLE;
```

## DRV\_AK4954\_CHANNEL Type

Identifies Left/Right Audio channel

## Description

AK4954 Audio Channel

This enumeration identifies Left/Right Audio channel

## Remarks

None.

## C

```
typedef enum DRV_AK4954_CHANNEL@1 DRV_AK4954_CHANNEL;
```

## DRV\_AK4954\_COMMAND\_EVENT\_HANDLER Type

Pointer to a AK4954 Driver Command Event Handler Function

## Description

AK4954 Driver Command Event Handler Function

This data type defines the required function signature for the AK4954 driver command event handling callback function.

A command is a control instruction to the AK4954 Codec. Example Mute ON/OFF, Zero Detect Enable/Disable etc.

A client must register a pointer to a command event handling function who's function signature (parameter and return value types) match the types specified by this function pointer in order to receive command related event calls back from the driver.

The parameters and return values are described here and a partial example implementation is provided.

## Parameters

Parameters	Description
context	Value identifying the context of the application that registered the event handling function.

## Returns

None.

## Remarks

The occurrence of this call back means that the last control command was transferred successfully.

The context parameter contains a handle to the client context, provided at the time the event handling function was registered using the [DRV\\_AK4954\\_CommandEventHandlerSet](#) function. This context handle value is passed back to the client as the "context" parameter. It can be any value necessary to identify the client context or instance (such as a pointer to the client's data) instance of the client that made the buffer add request.

The event handler function executes in the control data driver interrupt context. It is recommended of the application to not perform process intensive or blocking operations with in this function.

## Example

```
void APP_AK4954CommandEventHandler( uintptr_t context )
{
    MY_APP_DATA_STRUCT pAppData = (MY_APP_DATA_STRUCT) context;
```

```
// Last Submitted command is completed.  
// Perform further processing here  
}
```

**C**

```
typedef void (* DRV_AK4954_COMMAND_EVENT_HANDLER)(uintptr_t contextHandle);
```

**DRV\_AK4954\_DIGITAL\_BLOCK\_CONTROL Type**

Identifies Bass-Boost Control function

**Description**

AK4954 Bass-Boost Control

This enumeration identifies the settings for Bass-Boost Control function.

**Remarks**

None.

**C**

```
typedef enum DRV_AK4954_DIGITAL_BLOCK_CONTROL@1 DRV_AK4954_DIGITAL_BLOCK_CONTROL;
```

**DRV\_AK4954\_INIT Type**

Defines the data required to initialize or reinitialize the AK4954 driver

**Description**

AK4954 Driver Initialization Data

This data type defines the data required to initialize or reinitialize the AK4954 Codec driver.

**Remarks**

None.

**C**

```
typedef struct DRV_AK4954_INIT@1 DRV_AK4954_INIT;
```

**DRV\_AK4954\_INT\_EXT\_MIC Type**

Identifies the Mic input source.

**Description**

AK4954 Mic Internal / External Input

This enumeration identifies the Mic input source.

**C**

```
typedef enum DRV_AK4954_INT_EXT_MIC@1 DRV_AK4954_INT_EXT_MIC;
```

**DRV\_AK4954\_MIC Type**

This is type DRV\_AK4954\_MIC.

**C**

```
typedef enum DRV_AK4954_MIC@1 DRV_AK4954_MIC;
```

## DRV\_AK4954\_MONO\_STEREO\_MIC Type

Identifies the Mic input as Mono / Stereo.

### Description

AK4954 Mic Mono / Stereo Input

This enumeration identifies the Mic input as Mono / Stereo.

### C

```
typedef enum DRV_AK4954_MONO_STEREO_MIC@1 DRV_AK4954_MONO_STEREO_MIC;
```

## SAMPLE\_LENGTH Type

in bits

### C

```
typedef enum SAMPLE_LENGTH@1 SAMPLE_LENGTH;
```

## DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_I2S Macro

for compatibility with old code

### C

```
#define DRV_AK4954_AUDIO_DATA_FORMAT_I2S DRV_AK4954_AUDIO_DATA_FORMAT_I2S_16BIT_24BIT // for compatibility with old code
```

## DRV\_AK4954\_BUFFER\_HANDLE\_INVALID Macro

Definition of an invalid buffer handle.

### Description

AK4954 Driver Invalid Buffer Handle

This is the definition of an invalid buffer handle. An invalid buffer handle is returned by [DRV\\_AK4954\\_BufferAddWrite\(\)](#) and the [DRV\\_AK4954\\_BufferAddRead\(\)](#) function if the buffer add request was not successful.

### Remarks

None

### C

```
#define DRV_AK4954_BUFFER_HANDLE_INVALID ((DRV_AK4954_BUFFER_HANDLE)(-1))
```

## DRV\_AK4954\_COUNT Macro

Number of valid AK4954 driver indices

### Description

AK4954 Driver Module Count

This constant identifies the maximum number of AK4954 Driver instances that should be defined by the application. Defining more instances than this constant will waste RAM memory space.

This constant can also be used by the application to identify the number of AK4954 instances on this microcontroller.

## Remarks

This value is part-specific.

## C

```
#define DRV_AK4954_COUNT
```

## DRV\_AK4954\_INDEX\_0 Macro

AK4954 driver index definitions

## Description

Driver AK4954 Module Index

These constants provide AK4954 driver index definition.

## Remarks

These constants should be used in place of hard-coded numeric literals. These values should be passed into the [DRV\\_AK4954\\_Initialize](#) and [DRV\\_AK4954\\_Open](#) routines to identify the driver instance in use.

## C

```
#define DRV_AK4954_INDEX_0 0
```

## DRV\_AK4954\_INDEX\_1 Macro

This is macro DRV\_AK4954\_INDEX\_1.

## C

```
#define DRV_AK4954_INDEX_1 1
```

## DRV\_AK4954\_INDEX\_2 Macro

This is macro DRV\_AK4954\_INDEX\_2.

## C

```
#define DRV_AK4954_INDEX_2 2
```

## DRV\_AK4954\_INDEX\_3 Macro

This is macro DRV\_AK4954\_INDEX\_3.

## C

```
#define DRV_AK4954_INDEX_3 3
```

## DRV\_AK4954\_INDEX\_4 Macro

This is macro DRV\_AK4954\_INDEX\_4.

## C

```
#define DRV_AK4954_INDEX_4 4
```

## DRV\_AK4954\_INDEX\_5 Macro

This is macro DRV\_AK4954\_INDEX\_5.

### C

```
#define DRV_AK4954_INDEX_5 5
```

## Files

### Files

Name	Description
drv_ak4954.h	AK4954 Codec Driver Interface header file
drv_ak4954_config_template.h	AK4954 Codec Driver Configuration Template.

### Description

#### drv\_ak4954.h

drv\_ak4954.h

### Summary

AK4954 Codec Driver Interface header file

### Description

AK4954 Codec Driver Interface

The AK4954 Codec device driver interface provides a simple interface to manage the AK4954 16/24/32-Bit Codec that can be interfaced to a Microchip microcontroller. This file provides the public interface definitions for the AK4954 Codec device driver.

#### drv\_ak4954\_config\_template.h

drv\_ak4954\_config\_template.h

### Summary

AK4954 Codec Driver Configuration Template.

### Description

AK4954 Codec Driver Configuration Template

These file provides the list of all the configurations that can be used with the driver. This file should not be included in the driver.

## GENERIC AUDIO DRIVER CODEC Library

This topic describes the Generic Codec Driver Library.

## Introduction

### Summary

This library provides an Applications Programming Interface (API) to manage the Generic Codec that is serially interfaced to the I<sup>2</sup>C and I<sup>2</sup>S peripherals of a Microchip microcontroller for the purpose of providing audio solutions.

## Description

### Description

The Generic Codec module is 24-bit Audio Codec from Cirrus Logic, which can operate in 16-, 20-, 24-, and 32-bit audio modes. The Generic Codec can be interfaced to Microchip microcontrollers through I<sup>2</sup>C and I<sup>2</sup>S serial interfaces. The I<sup>2</sup>C interface is used to send commands and receive status, and the I<sup>2</sup>S interface is used for audio data output (to headphones or line-out) and input (from microphone or line-in).

The Generic Codec can be configured as either an I<sup>2</sup>S clock slave (receives all clocks from the host), or I<sup>2</sup>S clock master (generates I<sup>2</sup>S clocks from a master clock input MCLK). Currently the driver only supports slave mode with headphone output and (optionally) internal or external microphone input.

A typical interface of Generic Codec to a Microchip microcontroller using an I<sup>2</sup>C and SSC interface (configured as I<sup>2</sup>S), with the Generic Codec set up as the I<sup>2</sup>S clock slave, is provided in the following diagram:

The Generic Codec supports the following features:

- Audio Interface Format: 16-/20-/24-/32-bit interface, LSB justified or I2S format (only 16 and 32-bit interfaces supported in the driver)
- Sampling Frequency Range: 8 kHz to 96 kHz
- Digital Volume Control: -71.625 to 0 dB in 192 steps (converted to a linear scale 0-255 in the driver)

## Using the Library

This topic describes the basic architecture of the Generic Codec Driver Library and provides information and examples on its use.

### Description

#### Interface Header File: `drv_Generic.h`

The interface to the Generic Codec Driver library is defined in the `audio/driver/codec/Generic/drv_Generic.h` header file. Any C language source (.c) file that uses the Generic Codec Driver library should include this header.

### Library Source Files:

The Generic Codec Driver library source files are provided in the `audio/driver/codec/Generic/src` directory. This folder may contain optional files and alternate implementations. Please refer to **Configuring the Library** for instructions on how to select optional features and to **Building the Library** for instructions on how to build the library.

### Example Applications:

This library is used by the following applications:

- `audio/apps/audio_tone`
- `audio/apps/microphone_loopback`

## Abstraction Model

This library provides a low-level abstraction of the Generic Codec Driver Library on the Microchip family microcontrollers with a convenient C language interface. This topic describes how that abstraction is modeled in software and introduces the library's interface.

### Description

The abstraction model shown in the following diagram depicts how the Generic Codec Driver is positioned in the MPLAB Harmony framework. The Generic Codec Driver uses the I2C and I2S drivers for control and audio data transfers to the Generic module.

#### Generic Driver Abstraction Model

## Library Overview

Refer to the Driver Library Overview section for information on how the driver operates in a system.

The Generic Codec Driver Library provides an API interface to transfer control commands and digital audio data to the serially interfaced Generic Codec module. The library interface routines are divided into various sub-sections, which address one of the

blocks or the overall operation of the Generic Codec Driver Library.

Library Interface Section	Description
System Functions	Provides system module interfaces, device initialization, deinitialization, reinitialization, tasks and status functions.
Client Setup Functions	Provides open and close functions.
Data Transfer Functions	Provides data transfer functions, such as Buffer Read and Write.
Settings Functions	Provides driver specific functions for settings, such as volume control and sampling rate.
Other Functions	Miscellaneous functions, such as getting the driver's version number and syncing to the LRCLK signal.
Data Types and Constants	These data types and constants are required while interacting and setting up the Generic Codec Driver Library.

 **Note:** All functions and constants in this section are named with the format DRV\_Generic\_xxx, where 'xxx' is a function name or constant. These names are redefined in the appropriate configuration's configuration.h file to the format DRV\_CODEC\_xxx using #defines so that code in the application that references the library can be written as generically as possible (e.g., by writing DRV\_CODEC\_Open instead of DRV\_Generic\_Open etc.). This allows the codec type to be changed in the MHC without having to modify the application's source code.

## How the Library Works

### How the Library Works

The library provides interfaces to support:

- System Functionality
- Client Functionality

## Setup (Initialization)

This topic describes system initialization, implementations, and includes a system access code example.

### Description

#### System Initialization

The system performs the initialization of the device driver with settings that affect only the instance of the device that is being initialized. During system initialization in the system\_init.c file, each instance of the Generic module would be initialized with the following configuration settings (either passed dynamically at run time using DRV\_Generic\_INIT or by using Initialization Overrides) that are supported by the specific Generic device hardware:

- Device requested power state: one of the System Module Power States. For specific details please refer to Data Types and Constants in the Library Interface section.
- I2C driver module index. The module index should be same as the one used in initializing the I2C Driver
- I2S driver module index. The module index should be same as the one used in initializing the I2S Driver
- Sampling rate
- Volume
- Audio data format. The audio data format should match with the audio data format settings done in I2S driver initialization
- Determines whether or not the microphone input is enabled

The DRV\_Generic\_Initialize API returns an object handle of the type SYS\_MODULE\_OBJ. The object handle returned by the Initialize interface would be used by the other system interfaces such as DRV\_Generic\_Deinitialize, DRV\_Generic\_Status and DRV\_I2S\_Tasks.

## Client Access

This topic describes driver initialization and provides a code example.

### Description

For the application to start using an instance of the module, it must call the DRV\_Generic\_Open function. The DRV\_Generic\_Open function provides a driver handle to the Generic Codec Driver instance for operations. If the driver is deinitialized using the function DRV\_Generic\_Deinitialize, the application must call the DRV\_Generic\_Open function again to set up the instance of the driver.

For the various options available for IO\_INTENT, please refer to Data Types and Constants in the Library Interface section.

 **Note:** It is necessary to check the status of driver initialization before opening a driver instance. The status of the Generic Codec Driver can be known by calling DRV\_Generic\_Status.

### Example:

```
DRV_HANDLE handle;
SYS_STATUS genericStatus;
genericStatus Status = DRV_Generic_Status(sysObjects.genericStatus DevObject);
if (SYS_STATUS_READY == genericStatus)
{
    // The driver can now be opened.
    appData.genericClient.handle = DRV_Generic_Open
        (DRV_Generic_INDEX_0, DRV_IO_INTENT_WRITE | DRV_IO_INTENT_EXCLUSIVE);
    if(appData.genericClient.handle != DRV_HANDLE_INVALID)
    {
        appData.state = APP_STATE_Generic_SET_BUFFER_HANDLER;
    }
    else
    {
        SYS_DEBUG(0, "Find out what's wrong \r\n");
    }
}
else
{
    /* Generic Driver Is not ready */
}
```

## Client Operations

This topic provides information on client operations.

### Description

Client operations provide the API interface for control command and audio data transfer to the Generic Codec.

The following Generic Codec specific control command functions are provided:

- DRV\_Generic\_SamplingRateSet
- DRV\_Generic\_SamplingRateGet
- DRV\_Generic\_VolumeSet
- DRV\_Generic\_VolumeGet
- DRV\_Generic\_MuteOn
- DRV\_Generic\_MuteOff

These functions schedule a non-blocking control command transfer operation. These functions submit the control command request to the Generic Codec. These functions submit the control command request to I2C Driver transmit queue, the request is

processed immediately if it is the first request, or processed when the previous request is complete.

DRV\_Generic\_BufferAddWrite, DRV\_Generic\_BufferAddRead, and DRV\_Generic\_BufferAddWriteRead are buffered data operation functions. These functions schedule non-blocking audio data transfer operations. These functions add the request to I2S Driver transmit or receive buffer queue depends on the request type, and are executed immediately if it is the first buffer, or executed later when the previous buffer is complete. The driver notifies the client with DRV\_Generic\_BUFFER\_EVENT\_COMPLETE, DRV\_Generic\_BUFFER\_EVENT\_ERROR, or DRV\_Generic\_BUFFER\_EVENT\_ABORT events.



**Note:** It is not necessary to close and reopen the client between multiple transfers.

## Configuring the Library

The configuration of the I2S Driver Library is based on the file configurations.h, as generated by the MHC.

This header file contains the configuration selection for the I2S Driver Library. Based on the selections made, the I2S Driver Library may support the selected features. These configuration settings will apply to all instances of the I2S Driver Library.

This header can be placed anywhere; however, the path of this header needs to be present in the include search path for a successful build. Refer to the Applications Help section for more details.

## System Configuration

### Macros

	Name	Description
	<a href="#">DRV_GENERICCODEC_AUDIO_DATA_FORMAT_MACRO</a>	Specifies the audio data format for the codec.
	<a href="#">DRV_GENERICCODEC_AUDIO_SAMPLING_RATE</a>	Specifies the initial baud rate for the codec.
	<a href="#">DRV_GENERICCODEC_CLIENTS_NUMBER</a>	Sets up the maximum number of clients that can be connected to any hardware instance.
	<a href="#">DRV_GENERICCODEC_I2C_DRIVER_MODULE_INDEX_IDxx</a>	Specifies the instance number of the I2C interface.
	<a href="#">DRV_GENERICCODEC_I2S_DRIVER_MODULE_INDEX_IDxx</a>	Specifies the instance number of the I2S interface.
	<a href="#">DRV_GENERICCODEC_INSTANCES_NUMBER</a>	Sets up the maximum number of hardware instances that can be supported
	<a href="#">DRV_GENERICCODEC_VOLUME</a>	Specifies the initial volume level.

### Description

#### DRV\_GENERICCODEC\_AUDIO\_DATA\_FORMAT\_MACRO Macro

Specifies the audio data format for the codec.

### Description

Generic Codec Audio Data Format

Sets up the length of each sample plus the format (I2S or left-justified) for the audio.

Valid choices are: "DATA\_16\_BIT\_LEFT\_JUSTIFIED", 16-bit Left Justified "DATA\_16\_BIT\_I2S", 16-bit I2S"  
"DATA\_32\_BIT\_LEFT\_JUSTIFIED", 32-bit Left Justified "DATA\_32\_BIT\_I2S", 32-bit I2S"

### C

```
#define DRV_GENERICCODEC_AUDIO_DATA_FORMAT_MACRO
```

## DRV\_GENERICCODEC\_AUDIO\_SAMPLING\_RATE Macro

Specifies the initial baud rate for the codec.

### Description

Generic Codec Baud Rate

Sets the initial baud rate (sampling rate) for the codec. Typical values are 8000, 16000, 44100, 48000, 88200 and 96000.

C

```
#define DRV_GENERICCODEC_AUDIO_SAMPLING_RATE
```

## DRV\_GENERICCODEC\_CLIENTS\_NUMBER Macro

Sets up the maximum number of clients that can be connected to any hardware instance.

### Description

Generic Codec Client Count Configuration

Sets up the maximum number of clients that can be connected to any hardware instance. Typically only one client could be connected to one hardware instance. This value represents the total number of clients to be supported across all hardware instances.

C

```
#define DRV_GENERICCODEC_CLIENTS_NUMBER
```

## DRV\_GENERICCODEC\_I2C\_DRIVER\_MODULE\_INDEX\_IDXx Macro

Specifies the instance number of the I2C interface.

### Description

Generic Codec I2C instance number

Specifies the instance number of the I2C interface being used by the MCU to send commands and receive status to and from the Generic Codec. enabled.

C

```
#define DRV_GENERICCODEC_I2C_DRIVER_MODULE_INDEX_IDXx
```

## DRV\_GENERICCODEC\_I2S\_DRIVER\_MODULE\_INDEX\_IDXx Macro

Specifies the instance number of the I2S interface.

### Description

Generic Codec I2S instance number

Specifies the instance number of the I2S interface being used by the MCU to send and receive audio data to and from the Generic Codec. enabled.

C

```
#define DRV_GENERICCODEC_I2S_DRIVER_MODULE_INDEX_IDXx
```

## DRV\_GENERICCODEC\_INSTANCES\_NUMBER Macro

Sets up the maximum number of hardware instances that can be supported

## Description

Generic Codec driver objects configuration

Sets up the maximum number of hardware instances that can be supported. It is recommended that this number be set exactly equal to the number of Generic Codec modules that are needed by an application, namely one.

## C

```
#define DRV_GENERICCODEC_INSTANCES_NUMBER
```

## DRV\_GENERICCODEC\_VOLUME Macro

Specifies the initial volume level.

## Description

Generic Codec Volume

Sets the initial volume level, in the range 0-255.

## Remarks

The value is mapped to an internal Generic Codec volume level in the range 0-192 using a logarithmic table so the input scale appears linear (128 is half volume).

## C

```
#define DRV_GENERICCODEC_VOLUME
```

## Configuring MHC

Provides examples on how to configure the MPLAB Harmony Configurator (MHC) for a specific driver.

## Description

When building a new application, start by creating a 32-bit MPLAB Harmony 3 project in MPLAB X IDE by selecting *File > New Project*. Choose the Configuration name based on the BSP, and select the appropriate processor (such as ATSAME70Q21B).

In the MHC, under Available Components select the appropriate BSP, such as SAM E70 Xplained Ultra. Under *Audio>Templates*, double-click on a codec template such as Generic. Answer Yes to all questions.

You should end up with a project graph that looks like this, after rearranging the boxes:

Click on the Generic Driver component (not Generic Codec) and the following menu will be displayed in the Configurations Options:

- **I<sup>2</sup>C Driver Used** will display the driver instance used for the I<sup>2</sup>C interface.
- **I<sup>2</sup>S Driver Used** will display the driver instance used for the I<sup>2</sup>S interface.
- **Usage Mode** indicates whether the Generic is a Master (supplies I<sup>2</sup>S clocks) or a Slave (MCU supplies I<sup>2</sup>S clocks).
- **Number of Generic Clients** indicates the maximum number of clients that can be connected to the Generic Driver.
- **Sampling Rate** indicates the number of samples per second per channel, 8000 to 96,000.
- **Volume** indicates the volume in a linear scale from 0-255.
- **Audio Data Format** is either
  - 24-bit Left Justified (ADC), 24-bit Right-justified(DAC)
  - 24-bit Left Justified (ADC), 16-bit Right-justified(DAC)
  - 24-bit Left Justified (ADC), 24-bit Left-justified(DAC)
  - 24/16-bit I2S
  - 32-bit Left Justified (ADC), 32-bit Left-justified(DAC)
  - 32-bit I2S

It must match the audio protocol and data length set up in either the SSC or I2S PLIB.

- **Microphone/Line Input** selects which microphone or line input is selected, either:
  - Internal Mic (mounted on the Generic daughterboard)

- External Mic Input
- Line Input

If External Mic input or Line Input is selected, then the following option is provided:

- **Ext Mic Gain in dB range 0(min) to 31(max)**

If External Mic input is selected, then the following option is provided:

- **Enable Microphone Bias** should be checked if using an electret microphone.

You can also bring in the Generic Driver by itself, by double clicking Generic under Audio->Driver->Codec in the Available Components list. You will then need to add any additional needed components manually and connect them together.

Note that the Generic requires the TCx Peripheral Library and TIME System Service in order to perform some of its internal timing sequences.

## Building the Library

This section lists the files that are available in the Generic Codec Driver Library.

### Description

This section lists the files that are available in the `src` folder of the Generic Codec Driver. It lists which files need to be included in the build based on either a hardware feature present on the board or configuration option selected by the system.

The following three tables list and describe the header (`.h`) and source (`.c`) files that implement this library. The parent folder for these files is `audio/driver/codec/Generic`.

### Interface File(s)

This table lists and describes the header files that must be included (i.e., using `#include`) by any code that uses this library.

Source File Name	Description
<code>drv_genericcodec.h</code>	Header file that exports the driver API.

### Required File(s)

 **MHC** All of the required files listed in the following table are automatically added into the MPLAB X IDE project by the MHC when the library is selected for use.

This table lists and describes the source and header files that must always be included in the MPLAB X IDE project to build this library.

Source File Name	Description
<code>/src/drv_genericcodec.c</code>	This file contains implementation of the Generic Codec Driver.

### Optional File(s)

This table lists and describes the source and header files that may optionally be included if required for the desired implementation.

Source File Name	Description
N/A	No optional files are available for this library.

### Module Dependencies

The Generic Codec Driver Library depends on the following modules:

- I2S Driver Library
- I2C Driver Library

## Library Interface

### Client Setup Functions

	Name	Description
=♀	<a href="#">DRV_GENERICCODEC_Open</a>	Opens the specified Generic Codec driver instance and returns a handle to it
=♀	<a href="#">DRV_GENERICCODEC_Close</a>	Closes an opened-instance of the Generic Codec driver
=♀	<a href="#">DRV_GENERICCODEC_BufferEventHandlerSet</a>	This function allows a client to identify a buffer event handling function for the driver to call back when queued buffer transfers have finished.
=♀	<a href="#">DRV_GENERICCODEC_CommandEventHandlerSet</a>	This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

### Data Types and Constants

	Name	Description
	<a href="#">DRV_GENERICCODEC_BUFFER_EVENT</a>	Identifies the possible events that can result from a buffer add request.
	<a href="#">DRV_GENERICCODEC_BUFFER_EVENT_HANDLER</a>	Pointer to a Generic Codec Driver Buffer Event handler function
	<a href="#">DRV_GENERICCODEC_BUFFER_HANDLE</a>	Handle identifying a write buffer passed to the driver.
	<a href="#">DRV_GENERICCODEC_CHANNEL</a>	Identifies Left/Right Audio channel
	<a href="#">DRV_GENERICCODEC_COMMAND_EVENT_HANDLER</a>	Pointer to a Generic Codec Driver Command Event Handler Function
	<a href="#">DRV_GENERICCODEC_INIT</a>	Defines the data required to initialize or reinitialize the Generic Codec driver
	<a href="#">DRV_GENERICCODEC_BUFFER_HANDLE_INVALID</a>	Definition of an invalid buffer handle.
	<a href="#">DRV_GENERICCODEC_COUNT</a>	Number of valid Generic Codec driver indices
	<a href="#">DRV_GENERICCODEC_INDEX_0</a>	Generic Codec driver index definitions
	<a href="#">DRV_GENERICCODEC_INDEX_1</a>	This is macro DRV_GENERICCODEC_INDEX_1.
	<a href="#">DRV_GENERICCODEC_INDEX_2</a>	This is macro DRV_GENERICCODEC_INDEX_2.
	<a href="#">DRV_GENERICCODEC_INDEX_3</a>	This is macro DRV_GENERICCODEC_INDEX_3.
	<a href="#">DRV_GENERICCODEC_INDEX_4</a>	This is macro DRV_GENERICCODEC_INDEX_4.
	<a href="#">DRV_GENERICCODEC_INDEX_5</a>	This is macro DRV_GENERICCODEC_INDEX_5.
	<a href="#">DRV_GENERICCODEC_AUDIO_DATA_FORMAT</a>	Identifies the Serial Audio data interface format.

### Data Transfer Functions

	Name	Description
=♀	<a href="#">DRV_GENERICCODEC_BufferAddRead</a>	Schedule a non-blocking driver read operation.
=♀	<a href="#">DRV_GENERICCODEC_BufferAddWrite</a>	Schedule a non-blocking driver write operation.
=♀	<a href="#">DRV_GENERICCODEC_BufferAddWriteRead</a>	Schedule a non-blocking driver write-read operation.
=♀	<a href="#">DRV_GENERICCODEC_ReadQueuePurge</a>	Removes all buffer requests from the read queue.
=♀	<a href="#">DRV_GENERICCODEC_WriteQueuePurge</a>	Removes all buffer requests from the write queue.

### Other Functions

	Name	Description
=♀	<a href="#">DRV_GENERICCODEC_GetI2SDriver</a>	Get the handle to the I2S driver for this codec instance.
=♀	<a href="#">DRV_GENERICCODEC_LRCLK_Sync</a>	Synchronize to the start of the I2S LRCLK (left/right clock) signal

## Settings Functions

	Name	Description
≡◊	<a href="#">DRV_GENERICCODEC_MicGainGet</a>	This function gets the microphone gain for the Generic Codec.
≡◊	<a href="#">DRV_GENERICCODEC_MicGainSet</a>	This function sets the microphone gain for the Generic Codec CODEC.
≡◊	<a href="#">DRV_GENERICCODEC_MicMuteOff</a>	Umutes th Generic Codec's microphone input.
≡◊	<a href="#">DRV_GENERICCODEC_MicMuteOn</a>	Mutes the Generic Codec's microphone input
≡◊	<a href="#">DRV_GENERICCODEC_MuteOff</a>	This function disables Generic Codec output for soft mute.
≡◊	<a href="#">DRV_GENERICCODEC_MuteOn</a>	This function allows Generic Codec output for soft mute on.
≡◊	<a href="#">DRV_GENERICCODEC_SamplingRateGet</a>	This function gets the sampling rate set on the Generic Codec.
≡◊	<a href="#">DRV_GENERICCODEC_SamplingRateSet</a>	This function sets the sampling rate of the media stream.
≡◊	<a href="#">DRV_GENERICCODEC_VersionGet</a>	This function returns the version of Generic Codec driver
≡◊	<a href="#">DRV_GENERICCODEC_VersionStrGet</a>	This function returns the version of Generic Codec driver in string format.
≡◊	<a href="#">DRV_GENERICCODEC_VolumeGet</a>	This function gets the volume for Generic Codec.
≡◊	<a href="#">DRV_GENERICCODEC_VolumeSet</a>	This function sets the volume for Generic Codec.

## System Interaction Functions

	Name	Description
≡◊	<a href="#">DRV_GENERICCODEC_Initialize</a>	Initializes hardware and data for the instance of the Generic Codec module
≡◊	<a href="#">DRV_GENERICCODEC_Deinitialize</a>	Deinitializes the specified instance of the Generic Codec driver module
≡◊	<a href="#">DRV_GENERICCODEC_Status</a>	Gets the current status of the Generic Codec driver module.
≡◊	<a href="#">DRV_GENERICCODEC_Tasks</a>	Maintains the driver's control and data interface state machine.

## Description

### **System Interaction Functions**

#### **DRV\_GENERICCODEC\_Initialize Function**

```
SYS_MODULE_OBJ DRV_GENERICCODEC_Initialize
(
const SYS_MODULE_INDEX drvIndex,
const SYS_MODULE_INIT *const init
);
```

## Summary

Initializes hardware and data for the instance of the Generic Codec module

## Description

This routine initializes the Generic Codec driver instance for the specified driver index, making it ready for clients to open and use it. The initialization data is specified by the init parameter. The initialization may fail if the number of driver objects allocated are insufficient or if the specified driver instance is already initialized.

## Preconditions

DRV\_I2S\_Initialize must be called before calling this function to initialize the data interface of this Codec driver.  
DRV\_I2C\_Initialize must be called if SPI driver is used for handling the control interface of this Codec driver.

## Parameters

Parameters	Description
drvIndex	Identifier for the driver instance to be initialized
init	Pointer to the data structure containing any data necessary to initialize the hardware. This pointer may be null if no data is required and default initialization is to be used.

## Returns

If successful, returns a valid handle to a driver instance object. Otherwise, it returns SYS\_MODULE\_OBJ\_INVALID.

## Remarks

This routine must be called before any other Generic Codec routine is called.

This routine should only be called once during system initialization unless [DRV\\_GENERICCODEC\\_Deinitialize](#) is called to deinitialize the driver instance. This routine will NEVER block for hardware access.

## Example

```
DRV_GENERICCODEC_INIT           init;
SYS_MODULE_OBJ                  objectHandle;

init->inUse                    = true;
init->status                   = SYS_STATUS_BUSY;
init->numClients                = 0;
init->i2sDriverModuleIndex      = genericodecInit->i2sDriverModuleIndex;
init->i2cDriverModuleIndex      = genericodecInit->i2cDriverModuleIndex;
init->samplingRate              = DRV_GENERICCODEC_AUDIO_SAMPLING_RATE;
init->audioDataFormat          = DRV_GENERICCODEC_AUDIO_DATA_FORMAT_MACRO;

init->isInInterruptContext     = false;

init->commandCompleteCallback   = (DRV_GENERICCODEC_COMMAND_EVENT_HANDLER) 0;
init->commandContextData        = 0;
init->mclk_multiplier           = DRV_GENERICCODEC_MCLK_SAMPLE_FREQ_MULTIPLIER;

objectHandle = DRV_GENERICCODEC_Initialize(DRV_GENERICCODEC_0, (SYS_MODULE_INIT*)init);
if (SYS_MODULE_OBJ_INVALID == objectHandle)
{
    // Handle error
}
```

## C

```
SYS_MODULE_OBJ DRV_GENERICCODEC_Initialize(const SYS_MODULE_INDEX drvIndex, const
SYS_MODULE_INIT * const init);
```

## DRV\_GENERICCODEC\_Deinitialize Function

```
void DRV_GENERICCODEC_Deinitialize( SYS_MODULE_OBJ object)
```

## Summary

Deinitializes the specified instance of the Generic Codec driver module

## Description

Deinitializes the specified instance of the Generic Codec driver module, disabling its operation (and any hardware). Invalidates all the internal data.

## Preconditions

Function [DRV\\_GENERICCODEC\\_Initialize](#) should have been called before calling this function.

## Parameters

Parameters	Description
object	Driver object handle, returned from the <a href="#">DRV_GENERICCODEC_Initialize</a> routine

## Returns

None.

## Remarks

Once the Initialize operation has been called, the De-initialize operation must be called before the Initialize operation can be called again. This routine will NEVER block waiting for hardware.

## Example

```
SYS_MODULE_OBJ          object;      // Returned from DRV_GENERICCODEC_Initialize
SYS_STATUS              status;

DRV_GENERICCODEC_Deinitialize(object);

status = DRV_GENERICCODEC_Status(object);
if (SYS_MODULE_DEINITIALIZED != status)
{
    // Check again later if you need to know
    // when the driver is deinitialized.
}

void DRV_GENERICCODEC_Deinitialize(SYS_MODULE_OBJ object);
```

## C

## DRV\_GENERICCODEC\_Status Function

SYS\_STATUS DRV\_GENERICCODEC\_Status( SYS\_MODULE\_OBJ object)

## Summary

Gets the current status of the Generic Codec driver module.

## Description

This routine provides the current status of the Generic Codec driver module.

## Preconditions

Function [DRV\\_GENERICCODEC\\_Initialize](#) should have been called before calling this function.

## Parameters

Parameters	Description
object	Driver object handle, returned from the <a href="#">DRV_GENERICCODEC_Initialize</a> routine

## Returns

SYS\_STATUS\_DEINITIALIZED - Indicates that the driver has been deinitialized

SYS\_STATUS\_READY - Indicates that any previous module operation for the specified module has completed

SYS\_STATUS\_BUSY - Indicates that a previous module operation for the specified module has not yet completed

SYS\_STATUS\_ERROR - Indicates that the specified module is in an error state

## Remarks

A driver can opened only when its status is SYS\_STATUS\_READY.

## Example

```
SYS_MODULE_OBJ          object;      // Returned from DRV_GENERICCODEC_Initialize
```

```

SYS_STATUS           GENERICCODECStatus;

GENERICCODECStatus = DRV_GENERICCODEC_Status(object);
if (SYS_STATUS_READY == GENERICCODECStatus)
{
    // This means the driver can be opened using the
    // DRV_GENERICCODEC_Open() function.
}

```

**C**

```
SYS_STATUS DRV_GENERICCODEC_Status(SYS_MODULE_OBJ object);
```

**DRV\_GENERICCODEC\_Tasks Function**

```
void DRV_GENERICCODEC_Tasks(SYS_MODULE_OBJ object);
```

**Summary**

Maintains the driver's control and data interface state machine.

**Description**

This routine is used to maintain the driver's internal control and data interface state machine and implement its control and data interface implementations. This function should be called from the SYS\_Tasks() function.

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.

**Parameters**

Parameters	Description
object	Object handle for the specified driver instance (returned from <a href="#">DRV_GENERICCODEC_Initialize</a> )

**Returns**

None.

**Remarks**

This routine is normally not called directly by an application. It is called by the system's Tasks routine (SYS\_Tasks).

**Example**

```

SYS_MODULE_OBJ      object;      // Returned From DRV_GENERICCODEC_Initialize

while (true)
{
    DRV_GENERICCODEC_Tasks (object);

    // Do other tasks
}

```

**C**

```
void DRV_GENERICCODEC_Tasks(SYS_MODULE_OBJ object);
```

**Client Setup Functions****DRV\_GENERICCODEC\_Open Function**

DRV\_HANDLE DRV\_GENERICCODEC\_Open

```

(
const SYS_MODULE_INDEX drvIndex,
const DRV_IO_INTENT ioIntent
)

```

## Summary

Opens the specified Generic Codec driver instance and returns a handle to it

## Description

This routine opens the specified Generic Codec driver instance and provides a handle that must be provided to all other client-level operations to identify the caller and the instance of the driver. The ioIntent parameter defines how the client interacts with this driver instance.

The DRV\_IO\_INTENT\_BLOCKING and DRV\_IO\_INTENT\_NONBLOCKING ioIntent options are not relevant to this driver. All the data transfer functions of this driver are non blocking.

Generic Codec can be opened with DRV\_IO\_INTENT\_WRITE, or DRV\_IO\_INTENT\_READ or DRV\_IO\_INTENT\_WRITEREAD io\_intent option. This decides whether the driver is used for headphone output, or microphone input or both modes simultaneously. Specifying a DRV\_IO\_INTENT\_EXCLUSIVE will cause the driver to provide exclusive access to this client. The driver cannot be opened by any other client.

## Preconditions

Function [DRV\\_GENERICCODEC\\_Initialize](#) must have been called before calling this function.

## Parameters

Parameters	Description
drvIndex	Identifier for the object instance to be opened
ioIntent	Zero or more of the values from the enumeration DRV_IO_INTENT "ORed" together to indicate the intended use of the driver. See function description for details.

## Returns

If successful, the routine returns a valid open-instance handle (a number identifying both the caller and the module instance).

If an error occurs, the return value is DRV\_HANDLE\_INVALID. Error can occur

- if the number of client objects allocated via [DRV\\_GENERICCODEC\\_CLIENTS\\_NUMBER](#) is insufficient.
- if the client is trying to open the driver but driver has been opened exclusively by another client.
- if the driver hardware instance being opened is not initialized or is invalid.
- if the ioIntent options passed are not relevant to this driver.

## Remarks

The handle returned is valid until the [DRV\\_GENERICCODEC\\_Close](#) routine is called. This routine will NEVER block waiting for hardware. If the requested intent flags are not supported, the routine will return DRV\_HANDLE\_INVALID. This function is thread safe in a RTOS application. It should not be called in an ISR.

## Example

```

DRV_HANDLE handle;

handle = DRV_GENERICCODEC_Open(DRV_GENERICCODEC_INDEX_0, DRV_IO_INTENT_WRITEREAD |
DRV_IO_INTENT_EXCLUSIVE);
if (DRV_HANDLE_INVALID == handle)
{
    // Unable to open the driver
    // May be the driver is not initialized or the initialization
    // is not complete.
}

```

## C

```
DRV_HANDLE DRV_GENERICCODEC_Open(const SYS_MODULE_INDEX iDriver, const DRV_IO_INTENT ioIntent);
```

## DRV\_GENERICCODEC\_Close Function

```
void DRV_GENERICCODEC_Close( DRV_Handle handle )
```

### Summary

Closes an opened-instance of the Generic Codec driver

### Description

This routine closes an opened-instance of the Generic Codec driver, invalidating the handle. Any buffers in the driver queue that were submitted by this client will be removed. After calling this routine, the handle passed in "handle" must not be used with any of the remaining driver routines. A new handle must be obtained by calling [DRV\\_GENERICCODEC\\_Open](#) before the caller may use the driver again

### Preconditions

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

### Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

### Returns

- None

### Remarks

Usually there is no need for the driver client to verify that the Close operation has completed. The driver will abort any ongoing operations when this routine is called.

### Example

```
DRV_HANDLE handle; // Returned from DRV_GENERICCODEC_Open

DRV_GENERICCODEC_Close(handle);
```

### C

```
void DRV_GENERICCODEC_Close(const DRV_HANDLE handle);
```

## DRV\_GENERICCODEC\_BufferEventHandlerSet Function

```
void DRV_GENERICCODEC_BufferEventHandlerSet
(
    DRV_HANDLE handle,
    const DRV_GENERICCODEC_BUFFER_EVENT_HANDLER eventHandler,
    const uintptr_t contextHandle
)
```

### Summary

This function allows a client to identify a buffer event handling function for the driver to call back when queued buffer transfers have finished.

### Description

This function allows a client to identify a buffer event handling function for the driver to call back when queued buffer transfers have finished. When a client calls [DRV\\_GENERICCODEC\\_BufferAddWrite](#) function, it is provided with a handle identifying the buffer that was added to the driver's buffer queue. The driver will pass this handle back to the client by calling "eventHandler" function when the buffer transfer has completed.

The event handler should be set before the client performs any "buffer add" operations that could generate events. The event handler once set, persists until the client closes the driver or sets another event handler (which could be a "NULL" pointer to indicate no callback).

## Preconditions

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.  
[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
eventHandler	Pointer to the event handler function.
context	The value of parameter will be passed back to the client unchanged, when the eventHandler function is called. It can be used to identify any client specific data object that identifies the instance of the client module (for example, it may be a pointer to the client module's state structure).

## Returns

None.

## Remarks

If the client does not want to be notified when the queued buffer transfer has completed, it does not need to register a callback.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

// Client registers an event handler with driver

DRV_GENERICCODEC_BufferEventHandlerSet(myGENERICCODECHandle,
                                       DRV_GENERICCODECBufferEventHandler, (uintptr_t)&myAppObj);

DRV_GENERICCODEC_BufferAddWrite(myGENERICCODECHandle, &bufferHandle
                                myBuffer, MY_BUFFER_SIZE);

if(DRV_GENERICCODEC_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void DRV_GENERICCODECBufferEventHandler(DRV_GENERICCODEC_BUFFER_EVENT event,
                                         DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_GENERICCODEC_BUFFER_EVENT_COMPLETE:

            // This means the data was transferred.
            break;

        case DRV_GENERICCODEC_BUFFER_EVENT_ERROR:

            // Error handling here.
            break;
    }
}

```

```

    default:
        break;
}
}

```

**C**

```
void DRV_GENERICCODEC_BufferEventHandlerSet(DRV_HANDLE handle, const
DRV_GENERICCODEC_BUFFER_EVENT_HANDLER eventHandler, const uintptr_t contextHandle);
```

**DRV\_GENERICCODEC\_CommandEventHandlerSet Function**

```
void DRV_GENERICCODEC_CommandEventHandlerSet
(
DRV_HANDLE handle,
const      DRV_GENERICCODEC_COMMAND_EVENT_HANDLER eventHandler,
const uintptr_t contextHandle
)
```

**Summary**

This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

**Description**

This function allows a client to identify a command event handling function for the driver to call back when the last submitted command have finished.

The event handler should be set before the client performs any "Generic Codec Specific Client Routines" operations that could generate events. The event handler once set, persists until the client closes the driver or sets another event handler (which could be a "NULL" pointer to indicate no callback).

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.  
[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
eventHandler	Pointer to the event handler function.
context	The value of parameter will be passed back to the client unchanged, when the eventHandler function is called. It can be used to identify any client specific data object that identifies the instance of the client module (for example, it may be a pointer to the client module's state structure).

**Returns**

None.

**Remarks**

If the client does not want to be notified when the command has completed, it does not need to register a callback.

**Example**

```

MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

```

```

// Client registers an event handler with driver

DRV_GENERICCODEC_CommandEventHandlerSet(myGENERICCODECHandle,
    DRV_GENERICCODECCommandEventHandler, (uintptr_t)&myAppObj);

DRV_GENERICCODEC_DeEmphasisFilterSet(myGENERICCODECHandle,
DRV_GENERICCODEC_DEEMPHASIS_FILTER_44_1KHZ)

// Event is received when
// the buffer is processed.

void DRV_GENERICCODECCommandEventHandler(uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        // Last Submitted command is completed.
        // Perform further processing here
    }
}

```

**C**

```

void DRV_GENERICCODEC_CommandEventHandlerSet(DRV_HANDLE handle, const
DRV_GENERICCODEC_COMMAND_EVENT_HANDLER eventHandler, const uintptr_t contextHandle);

```

**Data Transfer Functions****DRV\_GENERICCODEC\_BufferAddRead Function**

```

void DRV_GENERICCODEC_BufferAddRead
(
const DRV_HANDLE handle,
    DRV_GENERICCODEC_BUFFER_HANDLE *bufferHandle,
void *buffer, size_t size
)

```

**Summary**

Schedule a non-blocking driver read operation.

**Description**

This function schedules a non-blocking read operation. The function returns with a valid buffer handle in the bufferHandle argument if the read request was scheduled successfully. The function adds the request to the hardware instance receive queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns [DRV\\_GENERICCODEC\\_BUFFER\\_HANDLE\\_INVALID](#)

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the buffer size is 0.
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a [DRV\\_GENERICCODEC\\_BUFFER\\_EVENT\\_COMPLETE](#) event if the buffer was processed successfully or [DRV\\_GENERICCODEC\\_BUFFER\\_EVENT\\_ERROR](#) event if the buffer was not processed successfully.

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec device instance and the [DRV\\_GENERICCODEC\\_Status](#) must have returned [SYS\\_STATUS\\_READY](#).

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.  
[DRV\\_IO\\_INTENT\\_READ](#) must have been specified in the [DRV\\_GENERICCODEC\\_Open](#) call.

## Parameters

Parameters	Description
handle	Handle of the Generic Codec instance as return by the <a href="#">DRV_GENERICCODEC_Open</a> function.
buffer	Data to be transmitted.
size	Buffer size in bytes.
bufferHandle	Pointer to an argument that will contain the return buffer handle.

## Returns

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_GENERICCODEC\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

## Remarks

This function is thread safe in a RTOS application. It can be called from within the Generic Codec Driver Buffer Event Handler that is registered by this client. It should not be called in the event handler associated with another Generic Codec driver instance. It should not otherwise be called directly in an ISR.

## C

```
void DRV_GENERICCODEC_BufferAddRead(const DRV_HANDLE handle, DRV_GENERICCODEC_BUFFER_HANDLE *bufferHandle, void * buffer, size_t size);
```

## DRV\_GENERICCODEC\_BufferAddWrite Function

```
void DRV_GENERICCODEC_BufferAddWrite
(
    const DRV_HANDLE handle,
    DRV_GENERICCODEC_BUFFER_HANDLE *bufferHandle,
    void *buffer, size_t size
)
```

## Summary

Schedule a non-blocking driver write operation.

## Description

This function schedules a non-blocking write operation. The function returns with a valid buffer handle in the bufferHandle argument if the write request was scheduled successfully. The function adds the request to the hardware instance transmit queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns [DRV\\_GENERICCODEC\\_BUFFER\\_HANDLE\\_INVALID](#):

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the buffer size is 0.
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a [DRV\\_GENERICCODEC\\_BUFFER\\_EVENT\\_COMPLETE](#) event if the buffer was processed successfully or [DRV\\_GENERICCODEC\\_BUFFER\\_EVENT\\_ERROR](#) event if the buffer was not processed successfully.

## Preconditions

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec device instance and the [DRV\\_GENERICCODEC\\_Status](#) must have returned [SYS\\_STATUS\\_READY](#).

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

[DRV\\_IO\\_INTENT\\_WRITE](#) must have been specified in the [DRV\\_GENERICCODEC\\_Open](#) call.

## Parameters

Parameters	Description
handle	Handle of the Generic Codec instance as return by the <a href="#">DRV_GENERICCODEC_Open</a> function.
buffer	Data to be transmitted.
size	Buffer size in bytes.
bufferHandle	Pointer to an argument that will contain the return buffer handle.

## Returns

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_GENERICCODEC\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

## Remarks

This function is thread safe in a RTOS application. It can be called from within the Generic Codec Driver Buffer Event Handler that is registered by this client. It should not be called in the event handler associated with another Generic Codec driver instance. It should not otherwise be called directly in an ISR.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

// Client registers an event handler with driver

DRV_GENERICCODEC_BufferEventHandlerSet(myGENERICCODECHandle,
                                      DRV_GENERICCODECBufferEventHandler, (uintptr_t)&myAppObj);

DRV_GENERICCODEC_BufferAddWrite(myGENERICCODECHandle, &bufferHandle
                                myBuffer, MY_BUFFER_SIZE);

if(DRV_GENERICCODEC_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void DRV_GENERICCODECBufferEventHandler(DRV_GENERICCODEC_BUFFER_EVENT event,
                                         DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_GENERICCODEC_BUFFER_EVENT_COMPLETE:

            // This means the data was transferred.
            break;

        case DRV_GENERICCODEC_BUFFER_EVENT_ERROR:

            // Error handling here.
            break;

        default:
            break;
    }
}

```

**C**

```
void DRV_GENERICCODEC_BufferAddWrite(const DRV_HANDLE handle, DRV_GENERICCODEC_BUFFER_HANDLE *bufferHandle, void * buffer, size_t size);
```

**DRV\_GENERICCODEC\_BufferAddWriteRead Function**

```
void DRV_GENERICCODEC_BufferAddWriteRead
(
    const DRV_HANDLE handle,
    DRV_GENERICCODEC_BUFFER_HANDLE *bufferHandle,
    void *transmitBuffer,
    void *receiveBuffer,
    size_t size
)
```

**Summary**

Schedule a non-blocking driver write-read operation.

**Description**

This function schedules a non-blocking write-read operation. The function returns with a valid buffer handle in the bufferHandle argument if the write-read request was scheduled successfully. The function adds the request to the hardware instance queue and returns immediately. While the request is in the queue, the application buffer is owned by the driver and should not be modified. The function returns DRV\_GENERICCODEC\_BUFFER\_EVENT\_COMPLETE:

- if a buffer could not be allocated to the request
- if the input buffer pointer is NULL
- if the client opened the driver for read only or write only
- if the buffer size is 0
- if the queue is full or the queue depth is insufficient

If the requesting client registered an event callback with the driver, the driver will issue a DRV\_GENERICCODEC\_BUFFER\_EVENT\_COMPLETE event if the buffer was processed successfully or DRV\_GENERICCODEC\_BUFFER\_EVENT\_ERROR event if the buffer was not processed successfully.

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec device instance and the [DRV\\_GENERICCODEC\\_Status](#) must have returned SYS\_STATUS\_READY.

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

[DRV\\_IO\\_INTENT\\_READWRITE](#) must have been specified in the [DRV\\_GENERICCODEC\\_Open](#) call.

**Parameters**

Parameters	Description
handle	Handle of the Generic Codec instance as returned by the <a href="#">DRV_GENERICCODEC_Open</a> function
bufferHandle	Pointer to an argument that will contain the return buffer handle
transmitBuffer	The buffer where the transmit data will be stored
receiveBuffer	The buffer where the received data will be stored
size	Buffer size in bytes

**Returns**

The bufferHandle parameter will contain the return buffer handle. This will be [DRV\\_GENERICCODEC\\_BUFFER\\_HANDLE\\_INVALID](#) if the function was not successful.

**Remarks**

This function is thread safe in a RTOS application. It can be called from within the Generic Codec Driver Buffer Event Handler that

is registered by this client. It should not be called in the event handler associated with another Generic Codec driver instance. It should not otherwise be called directly in an ISR.

This function is useful when there is valid read expected for every Generic Codec write. The transmit and receive size must be same.

## Example

```

MY_APP_OBJ myAppObj;
uint8_t mybufferTx[MY_BUFFER_SIZE];
uint8_t mybufferRx[MY_BUFFER_SIZE];
DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle;

// mygenericcodecHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

// Client registers an event handler with driver

DRV_GENERICCODEC_BufferEventHandlerSet(mygenericcodecHandle,
                                       DRV_GENERICCODECBufferEventHandler, (uintptr_t)&myAppObj);

DRV_GENERICCODEC_BufferAddWriteRead(myc genericcodecHandle, &bufferHandle,
                                    mybufferTx, mybufferRx, MY_BUFFER_SIZE);

if(DRV_GENERICCODEC_BUFFER_HANDLE_INVALID == bufferHandle)
{
    // Error handling here
}

// Event is received when
// the buffer is processed.

void DRV_GENERICCODECBufferEventHandler(DRV_GENERICCODEC_BUFFER_EVENT event,
                                         DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle)
{
    // contextHandle points to myAppObj.

    switch(event)
    {
        case DRV_GENERICCODEC_BUFFER_EVENT_COMPLETE:
            // This means the data was transferred.
            break;

        case DRV_GENERICCODEC_BUFFER_EVENT_ERROR:
            // Error handling here.
            break;

        default:
            break;
    }
}

```

## C

```

void DRV_GENERICCODEC_BufferAddWriteRead(const DRV_HANDLE handle,
                                         DRV_GENERICCODEC_BUFFER_HANDLE * bufferHandle, void * transmitBuffer, void * receiveBuffer,
                                         size_t size);

```

## DRV\_GENERICCODEC\_ReadQueuePurge Function

```
bool DRV_GENERICCODEC_ReadQueuePurge( const DRV_HANDLE handle )
```

### Summary

Removes all buffer requests from the read queue.

## Description

This function removes all the buffer requests from the read queue. The client can use this function to purge the queue on timeout or to remove unwanted stalled buffer requests or in any other use case.

## Preconditions

`DRV_I2S_Open` must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
<code>handle</code>	Handle of the communication channel as returned by the <code>DRV_GENERICCODEC_Open</code> function.

## Returns

True - Read queue purge is successful. False - Read queue purge has failed.

## Remarks

This function is thread safe when used in an RTOS environment. Avoid this function call from within the callback.

## Example

```
// myCodecHandle is the handle returned by the DRV_GENERICCODEC_Open function.
// Use DRV_GENERICCODEC_BufferAddRead to queue read requests

// Application timeout function, where remove queued buffers.
void APP_TimeOut(void)
{
    if(false == DRV_GENERICCODEC_ReadQueuePurge(myCodecHandle))
    {
        //Couldn't purge the read queue, try again.
    }
    else
    {
        //Queue purge successful.
    }
}
```

## C

```
bool DRV_GENERICCODEC_ReadQueuePurge(const DRV_HANDLE handle);
```

## DRV\_GENERICCODEC\_WriteQueuePurge Function

```
bool DRV_GENERICCODEC_WriteQueuePurge( const DRV_HANDLE handle )
```

## Summary

Removes all buffer requests from the write queue.

## Description

This function removes all the buffer requests from the write queue. The client can use this function to purge the queue on timeout or to remove unwanted stalled buffer requests or in any other use case.

## Preconditions

`DRV_GENERICCODEC_Open` must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
<code>handle</code>	Handle of the communication channel as returned by the <code>DRV_GENERICCODEC_Open</code> function.

## Returns

True - Write queue purge is successful. False - Write queue purge has failed.

## Remarks

This function is thread safe when used in an RTOS environment. Avoid this function call from within the callback.

## Example

```
// myCodecHandle is the handle returned by the DRV_GENERICCODEC_Open function.
// Use DRV_GENERICCODEC_BufferAddWrite to queue write requests

// Application timeout function, where remove queued buffers.
void APP_TimeOut(void)
{
    if(false == DRV_GENERICCODEC_WriteQueuePurge(myCodecHandle))
    {
        //Couldn't purge the write queue, try again.
    }
    else
    {
        //Queue purge successful.
    }
}
```

## C

```
bool DRV_GENERICCODEC_WriteQueuePurge(const DRV_HANDLE handle);
```

## Settings Functions

### DRV\_GENERICCODEC\_MicGainGet Function

```
uint8_t DRV_GENERICCODEC_MicGainGet(DRV_HANDLE handle)
```

## Summary

This function gets the microphone gain for the Generic Codec.

## Description

This function gets the current microphone gain programmed to the Generic Codec.

## Preconditions

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.  
[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

Microphone gain, in range 0-31.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;
```

```

uint8_t gain;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

gain = DRV_GENERICCODEC_MicGainGet(myGENERICCODECHandle);

```

**C**

```
uint8_t DRV_GENERICCODEC_MicGainGet(DRV_HANDLE handle);
```

**DRV\_GENERICCODEC\_MicGainSet Function**

```
void DRV_GENERICCODEC_MicGainSet(DRV_HANDLE handle, uint8_t gain)
```

**Summary**

This function sets the microphone gain for the Generic Codec CODEC.

**Description**

This functions sets the microphone gain value from 0-31

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.  
[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
gain	Gain value, in range 0-31

**Returns**

None.

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;
```

```
// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.
```

```
DRV_GENERICCODEC_MicGainSet(myGENERICCODECHandle, 15); //GENERICCODEC mic gain set to 15
```

**Remarks**

None.

**C**

```
void DRV_GENERICCODEC_MicGainSet(DRV_HANDLE handle, uint8_t gain);
```

**DRV\_GENERICCODEC\_MicMuteOff Function**

```
void DRV_GENERICCODEC_MicMuteOff(DRV_HANDLE handle)
```

**Summary**

Umutes th Generic Codec's microphone input.

**Description**

This function unmutes the Generic Codec's microphone input.

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

DRV_GENERICCODEC_MicMuteOff(myGENERICCODECHandle); //Generic Codec microphone unmuted
```

## C

```
void DRV_GENERICCODEC_MicMuteOff(DRV_HANDLE handle);
```

## DRV\_GENERICCODEC\_MicMuteOn Function

void DRV\_GENERICCODEC\_MicMuteOn(DRV\_HANDLE handle);

## Summary

Mutes the Generic Codec's microphone input

## Description

This function mutes the Generic Codec's microphone input

## Preconditions

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

DRV_GENERICCODEC_MicMuteOn(myGENERICCODECHandle); //Generic Codec microphone muted
```

**C**

```
void DRV_GENERICCODEC_MicMuteOn(DRV_HANDLE handle);
```

**DRV\_GENERICCODEC\_MuteOff Function**

```
void DRV_GENERICCODEC_MuteOff(DRV_HANDLE handle)
```

**Summary**

This function disables Generic Codec output for soft mute.

**Description**

This function disables Generic Codec output for soft mute.

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

**Returns**

None.

**Remarks**

None.

**Example**

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_BUFFER_HANDLE bufferHandle;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

DRV_GENERICCODEC_MuteOff(myGENERICCODECHandle); //Generic Codec output soft mute disabled
```

**C**

```
void DRV_GENERICCODEC_MuteOff(DRV_HANDLE handle);
```

**DRV\_GENERICCODEC\_MuteOn Function**

```
void DRV_GENERICCODEC_MuteOn(DRV_HANDLE handle);
```

**Summary**

This function allows Generic Codec output for soft mute on.

**Description**

This function Enables Generic Codec output for soft mute.

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_BUFFER_HANDLE bufferHandle;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

DRV_GENERICCODEC_MuteOn(myGENERICCODECHandle); //GENERICCODEC output soft muted
```

## C

```
void DRV_GENERICCODEC_MuteOn(DRV_HANDLE handle);
```

## DRV\_GENERICCODEC\_SamplingRateGet Function

```
uint32_t DRV_GENERICCODEC_SamplingRateGet(DRV_HANDLE handle)
```

## Summary

This function gets the sampling rate set on the Generic Codec.

## Description

This function gets the sampling rate set on the DAC Generic Codec.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Remarks

None.

## Example

```
uint32_t baudRate;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

baudRate = DRV_GENERICCODEC_SamplingRateGet(myGENERICCODECHandle);
```

## C

```
uint32_t DRV_GENERICCODEC_SamplingRateGet(DRV_HANDLE handle);
```

## DRV\_GENERICCODEC\_SamplingRateSet Function

```
void DRV_GENERICCODEC_SamplingRateSet(DRV_HANDLE handle, uint32_t samplingRate)
```

## Summary

This function sets the sampling rate of the media stream.

## Description

This function sets the media sampling rate for the client handle.

## Preconditions

The `DRV_GENERICCODEC_Initialize` routine must have been called for the specified Generic Codec driver instance.

`DRV_GENERICCODEC_Open` must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
samplingRate	Sampling frequency in Hz

## Returns

None.

## Remarks

None.

## Example

```
// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.
```

```
DRV_GENERICCODEC_SamplingRateSet(myGENERICCODECHandle, 48000); //Sets 48000 media sampling rate
```

## C

```
void DRV_GENERICCODEC_SamplingRateSet(DRV_HANDLE handle, uint32_t samplingRate);
```

## DRV\_GENERICCODEC\_VersionGet Function

```
uint32_t DRV_GENERICCODEC_VersionGet( void )
```

## Summary

This function returns the version of Generic Codec driver

## Description

The version number returned from the `DRV_GENERICCODEC_VersionGet` function is an unsigned integer in the following decimal format. \* 10000 + \* 100 + Where the numbers are represented in decimal and the meaning is the same as above. Note that there is no numerical representation of release type.

## Preconditions

None.

## Returns

returns the version of Generic Codec driver.

## Remarks

None.

## Example 1

For version "0.03a", return: 0 \* 10000 + 3 \* 100 + 0 For version "1.00", return: 1 \* 100000 + 0 \* 100 + 0

## Example 2

```
uint32_t GENERICCODECversion;
```

```
GENERICCODECversion = DRV_GENERICCODEC_VersionGet();
```

**C**

```
uint32_t DRV_GENERICCODEC_VersionGet();
```

**DRV\_GENERICCODEC\_VersionStrGet Function**

```
int8_t* DRV_GENERICCODEC_VersionStrGet(void)
```

**Summary**

This function returns the version of Generic Codec driver in string format.

**Description**

The DRV\_GENERICCODEC\_VersionStrGet function returns a string in the format: "[.][]]" Where: is the Generic Codec driver's version number. is the Generic Codec driver's version number. is an optional "patch" or "dot" release number (which is not included in the string if it equals "00"). is an optional release type ("a" for alpha, "b" for beta ? not the entire word spelled out) that is not included if the release is a production version (I.e. Not an alpha or beta).

The String does not contain any spaces. For example, "0.03a" "1.00"

**Preconditions**

None.

**Returns**

returns a string containing the version of Generic Codec driver.

**Remarks**

None

**Example**

```
int8_t *GENERICCODECstring;
GENERICCODECstring = DRV_GENERICCODEC_VersionStrGet();
```

**C**

```
int8_t* DRV_GENERICCODEC_VersionStrGet();
```

**DRV\_GENERICCODEC\_VolumeGet Function**

```
uint8_t DRV_GENERICCODEC_VolumeGet(DRV_HANDLE handle, DRV_GENERICCODEC_CHANNEL channel)
```

**Summary**

This function gets the volume for Generic Codec.

**Description**

This functions gets the current volume programmed to the Generic Codec.

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance. [DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
channel	argument indicating Left or Right or Both channel volume to be modified

## Returns

None.

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;
uint8_t volume;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

volume = DRV_GENERICCODEC_VolumeGet(myGENERICCODECHandle, DRV_GENERICCODEC_CHANNEL_LEFT);
```

**C**

```
uint8_t DRV_GENERICCODEC_VolumeGet(DRV_HANDLE handle, DRV_GENERICCODEC_CHANNEL channel);
```

## DRV\_GENERICCODEC\_VolumeSet Function

void DRV\_GENERICCODEC\_VolumeSet(DRV\_HANDLE handle, [DRV\\_GENERICCODEC\\_CHANNEL](#) channel, uint8\_t volume);

## Summary

This function sets the volume for Generic Codec.

## Description

This functions sets the volume value from 0-255.

## Preconditions

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

## Parameters

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine
channel	argument indicating Left or Right or Both channel volume to be modified
volume	volume value specified in the range 0-255 (0x00 to 0xFF)

## Returns

None

## Remarks

None.

## Example

```
// myAppObj is an application specific object.
MY_APP_OBJ myAppObj;

uint8_t mybuffer[MY_BUFFER_SIZE];
DRV_BUFFER_HANDLE bufferHandle;

// myGENERICCODECHandle is the handle returned
// by the DRV_GENERICCODEC_Open function.

DRV_GENERICCODEC_VolumeSet(myGENERICCODECHandle,DRV_GENERICCODEC_CHANNEL_LEFT, 120);
```

**C**

```
void DRV_GENERICCODEC_VolumeSet(DRV_HANDLE handle, DRV_GENERICCODEC_CHANNEL channel, uint8_t volume);
```

**Other Functions****DRV\_GENERICCODEC\_GetI2SDriver Function**

DRV\_HANDLE DRV\_GENERICCODEC\_GetI2SDriver(DRV\_HANDLE codecHandle)

**Summary**

Get the handle to the I2S driver for this codec instance.

**Description**

Returns the appropriate handle to the I2S based on the iolent member of the codec object.

**Preconditions**

The [DRV\\_GENERICCODEC\\_Initialize](#) routine must have been called for the specified Generic Codec driver instance.

[DRV\\_GENERICCODEC\\_Open](#) must have been called to obtain a valid opened device handle.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

**Returns**

- A handle to the I2S driver for this codec instance

**Remarks**

This allows the caller to directly access portions of the I2S driver that might not be available via the codec API.

**C**

```
DRV_HANDLE DRV_GENERICCODEC_GetI2SDriver(DRV_HANDLE codecHandle);
```

**DRV\_GENERICCODEC\_LRCLK\_Sync Function**

uint32\_t DRV\_GENERICCODEC\_LRCLK\_Sync (const DRV\_HANDLE handle);

**Summary**

Synchronize to the start of the I2S LRCLK (left/right clock) signal

**Description**

This function waits until low-to high transition of the I2S LRCLK (left/right clock) signal (high-low if Left-Justified format, this is determined by the PLIB). In the case where this signal is generated from a codec or other external source, this allows the caller to synchronize calls to the DMA with the LRCLK signal so the left/right channel association is valid.

**Preconditions**

None.

**Parameters**

Parameters	Description
handle	A valid open-instance handle, returned from the driver's open routine

## Returns

true if the function was successful, false if a timeout occurred (no transitions seen)

## Remarks

None.

## Example

```
// myGENERICCODECHANDLE is the handle returned
// by the DRV_GENERICCODEC_Open function.

DRV_GENERICCODEC_LRCLK_Sync(myGENERICCODECHANDLE);
```

## C

```
bool DRV_GENERICCODEC_LRCLK_Sync(const DRV_HANDLE handle);
```

## Data Types and Constants

### DRV\_GENERICCODEC\_BUFFER\_EVENT Type

Identifies the possible events that can result from a buffer add request.

## Description

Generic Codec Driver Events

This enumeration identifies the possible events that can result from a buffer add request caused by the client calling either the [DRV\\_GENERICCODEC\\_BufferAddWrite\(\)](#) or the [DRV\\_GENERICCODEC\\_BufferAddRead\(\)](#) function.

## Remarks

One of these values is passed in the "event" parameter of the event handling callback function that the client registered with the driver by calling the [DRV\\_GENERICCODEC\\_BufferEventHandlerSet](#) function when a buffer transfer request is completed.

## C

```
typedef enum DRV_GENERICCODEC_BUFFER_EVENT@1 DRV_GENERICCODEC_BUFFER_EVENT;
```

### DRV\_GENERICCODEC\_BUFFER\_EVENT\_HANDLER Type

Pointer to a Generic Codec Driver Buffer Event handler function

## Description

Generic Codec Driver Buffer Event Handler Function

This data type defines the required function signature for the Generic Codec driver buffer event handling callback function. A client must register a pointer to a buffer event handling function who's function signature (parameter and return value types) match the types specified by this function pointer in order to receive buffer related event calls back from the driver.

The parameters and return values are described here and a partial example implementation is provided.

## Parameters

Parameters	Description
event	Identifies the type of event
bufferHandle	Handle identifying the buffer to which the event relates
context	Value identifying the context of the application that registered the event handling function.

## Returns

None.

## Remarks

If the event is DRV\_GENERICCODEC\_BUFFER\_EVENT\_COMPLETE, this means that the data was transferred successfully.

If the event is DRV\_GENERICCODEC\_BUFFER\_EVENT\_ERROR, this means that the data was not transferred successfully.

The bufferHandle parameter contains the buffer handle of the buffer that failed. The

[DRV\\_GENERICCODEC\\_BufferProcessedSizeGet\(\)](#) function can be called to find out how many bytes were processed.

The bufferHandle parameter contains the buffer handle of the buffer that associated with the event.

The context parameter contains a handle to the client context, provided at the time the event handling function was registered using the [DRV\\_GENERICCODEC\\_BufferEventHandlerSet](#) function. This context handle value is passed back to the client as the "context" parameter. It can be any value necessary to identify the client context or instance (such as a pointer to the client's data) instance of the client that made the buffer add request.

The buffer handle in bufferHandle expires after this event handler exits. In that the buffer object that was allocated is deallocated by the driver after the event handler exits.

The event handler function executes in the data driver(i2S) peripheral's interrupt context when the driver is configured for interrupt mode operation. It is recommended of the application to not perform process intensive or blocking operations with in this function.

[DRV\\_GENERICCODEC\\_BufferAddWrite](#) function can be called in the event handler to add a buffer to the driver queue.

## Example

```
void DRV_GENERICCODECBufferEventHandler( DRV_GENERICCODEC_BUFFER_EVENT event,
                                         DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle,
                                         uintptr_t context )
{
    MY_APP_DATA_STRUCT pAppData = (MY_APP_DATA_STRUCT) context;

    switch(event)
    {
        case DRV_GENERICCODEC_BUFFER_EVENT_COMPLETE:
            // Handle the completed buffer.
            break;

        case DRV_GENERICCODEC_BUFFER_EVENT_ERROR:
        default:
            // Handle error.
            break;
    }
}
```

## C

```
typedef void (* DRV_GENERICCODEC_BUFFER_EVENT_HANDLER)(DRV_GENERICCODEC_BUFFER_EVENT event,
DRV_GENERICCODEC_BUFFER_HANDLE bufferHandle, uintptr_t contextHandle);
```

## DRV\_GENERICCODEC\_BUFFER\_HANDLE Type

Handle identifying a write buffer passed to the driver.

## Description

Generic Codec Driver Buffer Handle

A buffer handle value is returned by a call to the [DRV\\_GENERICCODEC\\_BufferAddWrite\(\)](#) or [DRV\\_GENERICCODEC\\_BufferAddRead\(\)](#) function. This handle is associated with the buffer passed into the function and it allows the application to track the completion of the data from (or into) that buffer.

The buffer handle value returned from the "buffer add" function is returned back to the client by the "event handler callback" function registered with the driver.

The buffer handle assigned to a client request expires when the client has been notified of the completion of the buffer transfer (after event handler function that notifies the client returns) or after the buffer has been retired by the driver if no event handler callback was set.

## Remarks

None

## C

```
typedef uintptr_t DRV_GENERICCODEC_BUFFER_HANDLE;
```

## DRV\_GENERICCODEC\_CHANNEL Type

Identifies Left/Right Audio channel

## Description

Generic Codec Audio Channel

This enumeration identifies Left/Right Audio channel

## Remarks

None.

## C

```
typedef enum DRV_GENERICCODEC_CHANNEL@1 DRV_GENERICCODEC_CHANNEL;
```

## DRV\_GENERICCODEC\_COMMAND\_EVENT\_HANDLER Type

Pointer to a Generic Codec Driver Command Event Handler Function

## Description

Generic Codec Driver Command Event Handler Function

This data type defines the required function signature for the Generic Codec driver command event handling callback function.

A command is a control instruction to the Generic Codec. Example Mute ON/OFF, Zero Detect Enable/Disable etc.

A client must register a pointer to a command event handling function who's function signature (parameter and return value types) match the types specified by this function pointer in order to receive command related event calls back from the driver.

The parameters and return values are described here and a partial example implementation is provided.

## Parameters

Parameters	Description
context	Value identifying the context of the application that registered the event handling function.

## Returns

None.

## Remarks

The occurrence of this call back means that the last control command was transferred successfully.

The context parameter contains a handle to the client context, provided at the time the event handling function was registered using the [DRV\\_GENERICCODEC\\_CommandEventHandlerSet](#) function. This context handle value is passed back to the client as the "context" parameter. It can be any value necessary to identify the client context or instance (such as a pointer to the client's data) instance of the client that made the buffer add request.

The event handler function executes in the control data driver interrupt context. It is recommended of the application to not perform process intensive or blocking operations with in this function.

## Example

```
void DRV_GENERICCODECCommandEventHandler( uintptr_t context )
{
    MY_APP_DATA_STRUCT pAppData = (MY_APP_DATA_STRUCT) context;
```

```

    // Last Submitted command is completed.
    // Perform further processing here
}

C

typedef void (* DRV_GENERICCODEC_COMMAND_EVENT_HANDLER)(uintptr_t contextHandle);

```

**DRV\_GENERICCODEC\_INIT Type**

Defines the data required to initialize or reinitialize the Generic Codec driver

**Description**

Generic Codec Driver Initialization Data

This data type defines the data required to initialize or reinitialize the Generic Codec driver.

**Remarks**

None.

**C**

```
typedef struct DRV_GENERICCODEC_INIT@1 DRV_GENERICCODEC_INIT;
```

**DRV\_GENERICCODEC\_BUFFER\_HANDLE\_INVALID Macro**

Definition of an invalid buffer handle.

**Description**

Generic Codec Driver Invalid Buffer Handle

This is the definition of an invalid buffer handle. An invalid buffer handle is returned by [DRV\\_GENERICCODEC\\_BufferAddWrite\(\)](#) and the [DRV\\_GENERICCODEC\\_BufferAddRead\(\)](#) function if the buffer add request was not successful.

**Remarks**

None.

**C**

```
#define DRV_GENERICCODEC_BUFFER_HANDLE_INVALID ((DRV_GENERICCODEC_BUFFER_HANDLE)(-1))
```

**DRV\_GENERICCODEC\_COUNT Macro**

Number of valid Generic Codec driver indices

**Description**

Generic Codec Driver Module Count

This constant identifies the maximum number of Generic Codec Driver instances that should be defined by the application. Defining more instances than this constant will waste RAM memory space.

This constant can also be used by the application to identify the number of Generic Codec instances on this microcontroller.

**Remarks**

This value is part-specific.

**C**

```
#define DRV_GENERICCODEC_COUNT
```

## DRV\_GENERICCODEC\_INDEX\_0 Macro

Generic Codec driver index definitions

### Description

Driver Generic Codec Module Index

These constants provide Generic Codec driver index definition.

### Remarks

These constants should be used in place of hard-coded numeric literals. These values should be passed into the [DRV\\_GENERICCODEC\\_Initialize](#) and [DRV\\_GENERICCODEC\\_Open](#) routines to identify the driver instance in use.

### C

```
#define DRV_GENERICCODEC_INDEX_0 0
```

## DRV\_GENERICCODEC\_INDEX\_1 Macro

This is macro DRV\_GENERICCODEC\_INDEX\_1.

### C

```
#define DRV_GENERICCODEC_INDEX_1 1
```

## DRV\_GENERICCODEC\_INDEX\_2 Macro

This is macro DRV\_GENERICCODEC\_INDEX\_2.

### C

```
#define DRV_GENERICCODEC_INDEX_2 2
```

## DRV\_GENERICCODEC\_INDEX\_3 Macro

This is macro DRV\_GENERICCODEC\_INDEX\_3.

### C

```
#define DRV_GENERICCODEC_INDEX_3 3
```

## DRV\_GENERICCODEC\_INDEX\_4 Macro

This is macro DRV\_GENERICCODEC\_INDEX\_4.

### C

```
#define DRV_GENERICCODEC_INDEX_4 4
```

## DRV\_GENERICCODEC\_INDEX\_5 Macro

This is macro DRV\_GENERICCODEC\_INDEX\_5.

### C

```
#define DRV_GENERICCODEC_INDEX_5 5
```

## DRV\_GENERICCODEC\_AUDIO\_DATA\_FORMAT Type

Identifies the Serial Audio data interface format.

### Description

Generic Codec Audio data format

This enumeration identifies Serial Audio data interface format.

### C

```
typedef enum DRV_GENERICCODEC_AUDIO_DATA_FORMAT@1 DRV_GENERICCODEC_AUDIO_DATA_FORMAT;
```

## Files

### Files

Name	Description
<a href="#">drv_genericcodec.h</a>	Generic Codec Driver Interface header file
<a href="#">drv_genericcodec_config_template.h</a>	Generic Codec Driver Configuration Template.

### Description

## drv\_genericcodec.h

drv\_genericcodec.h

### Summary

Generic Codec Driver Interface file

### Description

Generic Codec Driver Interface

The Generic Codec device driver interface provides a simple interface to manage a codec that can be interfaced to a Microchip microcontroller. This file provides the public interface definitions for the Generic Codec device driver.

## drv\_genericcodec\_config\_template.h

drv\_genericcodec\_config\_template.h

### Summary

Generic Codec Driver Configuration Template.

### Description

Generic Codec Driver Configuration Template

These file provides the list of all the configurations that can be used with the driver. This file should not be included in the driver.

# Audio Libraries Help

## Decoder Library Help

### Description

### Introduction

## ADPCM Decoder Library

### *Introduction*

Adaptive Differential Pulse Code Modulation (ADPCM) is a royalty-free audio codec. It is a lossy compression standard. It is a variant of Differential Pulse-Code Modulation (DPCM). The file format used to contain an ADPCM files, is the same as WAV.

Decoding is fast and requires little processing power.

Typical applications using ADPCM are for speech. This implementation currently supports 16 bit stereo.

### Using the Library

### Library Interface

#### Functions

	Name	Description
≡◊	<a href="#">ADPCM_Initialize</a>	This is function ADPCM_Initialize.
≡◊	<a href="#">ADPCM_Decoder</a>	Decode the ADPCM stream of inSize from input pointer into output pointer.
≡◊	<a href="#">ADPCM_GetChannels</a>	This is function ADPCM_GetChannels.
≡◊	<a href="#">ADPCM_Decoder_ConfigByteOrder</a>	Configure input ADPCM stream byte order.
≡◊	<a href="#">ADPCM_HdrGetFormat</a>	This is function ADPCM_HdrGetFormat.
≡◊	<a href="#">ADPCM_HdrGetBitsPerSample</a>	This is function ADPCM_HdrGetBitsPerSample.
≡◊	<a href="#">ADPCM_HdrGetDataLen</a>	This is function ADPCM_HdrGetDataLen.
≡◊	<a href="#">ADPCM_HdrGetFileSize</a>	This is function ADPCM_HdrGetFileSize.
≡◊	<a href="#">ADPCM_HdrGetBlockAlign</a>	This is function ADPCM_HdrGetBlockAlign.
≡◊	<a href="#">ADPCM_HdrGetBytesPerSec</a>	This is function ADPCM_HdrGetBytesPerSec.
≡◊	<a href="#">ADPCM_HdrGetNumOfChan</a>	This is function ADPCM_HdrGetNumOfChan.
≡◊	<a href="#">ADPCM_HdrGetSamplesPerSec</a>	This is function ADPCM_HdrGetSamplesPerSec.

## Data Types and Constants

	Name	Description
	<a href="#">ADPCMHEADER</a>	ADPCM WAV File Header
	<a href="#">ADPCM_HEADER_SIZE</a>	WAV Header Size

## Description

This section describes the Application Programming Interface (API) functions of the ADPCM Decoder Library.

## Functions

### ***ADPCM\_Initialize Function***

This is function ADPCM\_Initialize.

#### C

```
void ADPCM_Initialize(uint8_t * input);
```

### ***ADPCM\_Decoder Function***

```
bool ADPCM_Decoder
(uint8_t *input,
 uint16_t inSize,
 uint16_t *read,
 int16_t *output,
 uint16_t *written);
```

## Summary

Decode the ADPCM stream of inSize from input pointer into output pointer.

## Description

Decode the ADPCM stream of inSize from input pointer into output pointer.

## Parameters

Parameters	Description
inSize	Size of ADPCM input stream in bytes.
read	Size of ADPCM decoder has decoded after this function complete

## Returns

Pointer to the decoded data. written - Size of decoded data.

If successful, return true, otherwise, return false.

#### C

```
bool ADPCM_Decoder(uint8_t * input, uint16_t inSize, uint16_t * read, int16_t * output,
uint16_t * written);
```

### ***ADPCM\_GetChannels Function***

This is function ADPCM\_GetChannels.

**C**

```
uint8_t ADPCM_GetChannels();
```

***ADPCM\_Decoder\_ConfigByteOrder Function***

```
void ADPCM_Decoder_ConfigByteOrder (bool isLE);
```

**Summary**

Configure input ADPCM stream byte order.

**Description**

Configure input ADPCM stream byte order.

**Parameters**

Parameters	Description
isLE	True if ADPCM stream is in little endian format, otherwise, false.

**Returns**

None.

**C**

```
void ADPCM_Decoder_ConfigByteOrder(bool isLE);
```

***ADPCM\_HdrGetFormat Function***

This is function ADPCM\_HdrGetFormat.

**C**

```
int ADPCM_HdrGetFormat();
```

***ADPCM\_HdrGetBitsPerSample Function***

This is function ADPCM\_HdrGetBitsPerSample.

**C**

```
int ADPCM_HdrGetBitsPerSample();
```

***ADPCM\_HdrGetDataLen Function***

This is function ADPCM\_HdrGetDataLen.

**C**

```
int ADPCM_HdrGetDataLen();
```

***ADPCM\_HdrGetFileSize Function***

This is function ADPCM\_HdrGetFileSize.

**C**

```
unsigned int ADPCM_HdrGetFileSize();
```

## ***ADPCM\_HdrGetBlockAlign Function***

This is function ADPCM\_HdrGetBlockAlign.

**C**

```
int ADPCM_HdrGetBlockAlign();
```

## ***ADPCM\_HdrGetBytesPerSec Function***

This is function ADPCM\_HdrGetBytesPerSec.

**C**

```
int ADPCM_HdrGetBytesPerSec();
```

## ***ADPCM\_HdrGetNumOfChan Function***

This is function ADPCM\_HdrGetNumOfChan.

**C**

```
int ADPCM_HdrGetNumOfChan();
```

## ***ADPCM\_HdrGetSamplesPerSec Function***

This is function ADPCM\_HdrGetSamplesPerSec.

**C**

```
int ADPCM_HdrGetSamplesPerSec();
```

## **Data Types and Constants**

### ***ADPCMHEADER Type***

ADPCM WAV File Header

#### **Description**

ADPCM Audio File Header Structure

This structure is header structure of wav container.

**C**

```
typedef struct ADPCMHEADER@1 ADPCMHEADER;
```

### ***ADPCM\_HEADER\_SIZE Macro***

WAV Header Size

#### **Description**

ADPCM WAV File Header Size

## WAV Header Size

### C

```
#define ADPCM_HEADER_SIZE 44
```

## !!ADPCM FILES

### Files

Name	Description
<a href="#">adpcm_dec.h</a>	This is file adpcm_dec.h.

## *adpcm\_dec.h*

This is file adpcm\_dec.h.

## WAV Decoder Library

### *Introduction*

### *Using the Library*

### *Library Interface*

### Functions

	Name	Description
≡◊	<a href="#">WAV_Initialize_N</a>	This is function WAV_Initialize_N.
≡◊	<a href="#">WAV_Decoder</a>	This is function WAV_Decoder.
≡◊	<a href="#">WAV_GetChannels</a>	This is function WAV_GetChannels.
≡◊	<a href="#">WAV_UpdatePlaytime</a>	This is function WAV_UpdatePlaytime.
≡◊	<a href="#">WAV_GetDuration</a>	This is function WAV_GetDuration.
≡◊	<a href="#">WAV_HdrGetDataLen</a>	This is function WAV_HdrGetDataLen.
≡◊	<a href="#">WAV_HdrGetFileSize</a>	This is function WAV_HdrGetFileSize.
≡◊	<a href="#">WAV_GetSampleRate</a>	This is function WAV_GetSampleRate.
≡◊	<a href="#">WAV_GetBitRate</a>	This is function WAV_GetBitRate.
≡◊	<a href="#">WAV_HdrGetBytesPerSec</a>	This is function WAV_HdrGetBytesPerSec.
≡◊	<a href="#">WAV_HdrGetSamplesPerSec</a>	This is function WAV_HdrGetSamplesPerSec.
≡◊	<a href="#">WAV_GetAudioSize</a>	This is function WAV_GetAudioSize.

### Data Types and Constants

	Name	Description
	<a href="#">WAV_HEADER_SIZE</a>	This is macro WAV_HEADER_SIZE.

	<a href="#">WAV_HEAP_SIZE</a>	This is macro WAV_HEAP_SIZE.
	<a href="#">WAVE_FORMAT_ALAW</a>	This is macro WAVE_FORMAT_ALAW.
	<a href="#">WAVE_FORMAT_MULAW</a>	This is macro WAVE_FORMAT_MULAW.
	<a href="#">WAVE_FORMAT_PCM</a>	This is macro WAVE_FORMAT_PCM.

## Description

## Functions

### ***WAV\_Initialize\_N Function***

This is function WAV\_Initialize\_N.

#### C

```
void WAV_Initialize_N(uint8_t * input, SYS_FS_HANDLE wavFilehandle);
```

### ***WAV\_Decoder Function***

This is function WAV\_Decoder.

#### C

```
bool WAV_Decoder(uint8_t * input, uint16_t insize, uint16_t * read, int16_t * output, uint16_t * written);
```

### ***WAV\_GetChannels Function***

This is function WAV\_GetChannels.

#### C

```
uint8_t WAV_GetChannels();
```

### ***WAV\_UpdatePlaytime Function***

This is function WAV\_UpdatePlaytime.

#### C

```
uint32_t WAV_UpdatePlaytime();
```

### ***WAV\_GetDuration Function***

This is function WAV\_GetDuration.

#### C

```
uint32_t WAV_GetDuration();
```

### ***WAV\_HdrGetDataLen Function***

This is function WAV\_HdrGetDataLen.

**C**

```
int WAV_HdrGetDataLen();
```

### ***WAV\_HdrGetFileSize Function***

This is function WAV\_HdrGetFileSize.

**C**

```
unsigned int WAV_HdrGetFileSize();
```

### ***WAV\_GetSampleRate Function***

This is function WAV\_GetSampleRate.

**C**

```
uint32_t WAV_GetSampleRate();
```

### ***WAV\_GetBitRate Function***

This is function WAV\_GetBitRate.

**C**

```
uint32_t WAV_GetBitRate();
```

### ***WAV\_HdrGetBytesPerSec Function***

This is function WAV\_HdrGetBytesPerSec.

**C**

```
int WAV_HdrGetBytesPerSec();
```

### ***WAV\_HdrGetSamplesPerSec Function***

This is function WAV\_HdrGetSamplesPerSec.

**C**

```
int WAV_HdrGetSamplesPerSec();
```

### ***WAV\_GetAudioSize Function***

This is function WAV\_GetAudioSize.

**C**

```
uint32_t WAV_GetAudioSize();
```

## Data Types and Constants

### **WAV\_HEADER\_SIZE Macro**

This is macro WAV\_HEADER\_SIZE.

**C**

```
#define WAV_HEADER_SIZE 44
```

### **WAV\_HEAP\_SIZE Macro**

This is macro WAV\_HEAP\_SIZE.

**C**

```
#define WAV_HEAP_SIZE 1024
```

### **WAVE\_FORMAT\_ALAW Macro**

This is macro WAVE\_FORMAT\_ALAW.

**C**

```
#define WAVE_FORMAT_ALAW 0x0006
```

### **WAVE\_FORMAT\_MULAW Macro**

This is macro WAVE\_FORMAT\_MULAW.

**C**

```
#define WAVE_FORMAT_MULAW 0x0007
```

### **WAVE\_FORMAT\_PCM Macro**

This is macro WAVE\_FORMAT\_PCM.

**C**

```
#define WAVE_FORMAT_PCM 0x0001
```

## **!!WAV FILES**

### **Files**

Name	Description
wav_dec.h	This is file wav_dec.h.

## wav\_dec.h

This is file wav\_dec.h.

# Encoder Library Help

## Introduction

## ADPCM Encoder Library

### *Introduction*

### *Using the Library*

### *Library Interface*

#### Functions

	Name	Description
≡◊	<a href="#">adpcm_encoder_init</a>	This is function adpcm_encoder_init.
≡◊	<a href="#">adpcm_encode_frame</a>	This is function adpcm_encode_frame.
≡◊	<a href="#">adpcm_encoder_config_byteorder</a>	This is function adpcm_encoder_config_byteorder.
≡◊	<a href="#">adpcm_encoder_free</a>	This is function adpcm_encoder_free.

#### Description

#### Functions

### ***adpcm\_encoder\_init Function***

This is function adpcm\_encoder\_init.

#### C

```
bool adpcm_encoder_init();
```

## ***adpcm\_encode\_frame Function***

This is function adpcm\_encode\_frame.

### **C**

```
bool adpcm_encode_frame(void * pin, uint32_t insize, void * pout, uint32_t * outsize);
```

## ***adpcm\_encoder\_config\_byteorder Function***

This is function adpcm\_encoder\_config\_byteorder.

### **C**

```
void adpcm_encoder_config_byteorder(bool isLE);
```

## ***adpcm\_encoder\_free Function***

This is function adpcm\_encoder\_free.

### **C**

```
bool adpcm_encoder_free();
```

## **Data Types and Constants**

### **Files**

#### **Files**

Name	Description
<a href="#">adpcm_enc.h</a>	Contains the ADPCM encoder specific definitions and function prototypes.

#### **Description**

## ***adpcm\_enc.h***

adpcm\_enc.h

#### **Summary**

Contains the ADPCM encoder specific definitions and function prototypes.

#### **Description**

ADPCM Decoder Header File

This file contains the ADPCM encoder specific definitions and function prototypes.

## **PCM Encoder Library**

## Introduction

## Using the Library

## Library Interface

### Functions

	Name	Description
=◊	pcm_encoder_init	This is function pcm_encoder_init.
=◊	pcm_encode_frame	<p>@Function int ExampleFunctionName ( int param1, int param2 )</p> <p>@Summary Brief one-line description of the function.</p> <p>@Description Full description, explaining the purpose and usage of the function. Additional description in consecutive paragraphs separated by HTML paragraph breaks, as necessary.</p> <p>Type "JavaDoc" in the "How Do I?" IDE toolbar for more information on tags.</p> <p>@Precondition List and describe any required preconditions. If there are no preconditions, enter "None."</p> <p>@Parameters @param param1 Describe the first parameter to the function.</p> <p>@param param2 Describe the second parameter to the function.</p> <p>@Returns List (if feasible) and describe the return values of the function. 1 Indicates... <a href="#">more</a></p>
=◊	pcm_encoder_free	This is function pcm_encoder_free.

### Description

### Functions

#### pcm\_encoder\_init Function

This is function pcm\_encoder\_init.

### C

```
bool pcm_encoder_init(int channel, int inputSampleRate);
```

#### pcm\_encode\_frame Function

@Function int ExampleFunctionName ( int param1, int param2 )

@Summary Brief one-line description of the function.

@Description Full description, explaining the purpose and usage of the function.

Additional description in consecutive paragraphs separated by HTML paragraph breaks, as necessary.

Type "JavaDoc" in the "How Do I?" IDE toolbar for more information on tags.

@Precondition List and describe any required preconditions. If there are no preconditions, enter "None."

@Parameters @param param1 Describe the first parameter to the function.

@param param2 Describe the second parameter to the function.

@Returns List (if feasible) and describe the return values of the function. 1 Indicates an error occurred 0 Indicates an error did not occur  
@Remarks Describe any special behavior not described above.

Any additional remarks.

@Example @code if(ExampleFunctionName(1, 2) == 0) { return 3;

## C

```
bool pcm_encode_frame(void * pin, uint32_t insize, void * pout, uint32_t * outsize);
```

### ***pcm\_encoder\_free Function***

This is function pcm\_encoder\_free.

## C

```
bool pcm_encoder_free();
```

## Data Types and Constants

### ***Files***

#### **Files**

Name	Description
<a href="#">pcm_enc.h</a>	<ul style="list-style-type: none"><li>• WAV Encoder Header File</li></ul> <p>@Company Company Name @File Name wav_enc.h @Summary Brief description of the file. @Description Describe the purpose of this file.</p>

#### **Description**

### ***pcm\_enc.h***

• WAV Encoder Header File

@Company Company Name

@File Name wav\_enc.h

@Summary Brief description of the file.

@Description Describe the purpose of this file.

## Index

!

!!ADPCM FILES 198  
!!WAV FILES 201

### A

Abstraction Model 77, 157  
Abstration Model 114  
ADPCM Decoder Library 194  
ADPCM Encoder Library 202  
adpcm\_dec.h 198  
ADPCM\_Decoder function 195  
ADPCM\_Decoder\_ConfigByteOrder function 196  
adpcm\_enc.h 203  
adpcm\_encode\_frame function 203  
adpcm\_encoder\_config\_byteorder function 203  
adpcm\_encoder\_free function 203  
adpcm\_encoder\_init function 202  
ADPCM\_GetChannels function 195  
ADPCM\_HdrGetBitsPerSample function 196  
ADPCM\_HdrGetBlockAlign function 197  
ADPCM\_HdrGetBytesPerSec function 197  
ADPCM\_HdrGetDataLen function 196  
ADPCM\_HdrGetFileSize function 196  
ADPCM\_HdrGetFormat function 196  
ADPCM\_HdrGetNumOfChan function 197  
ADPCM\_HdrGetSamplesPerSec function 197  
ADPCM\_HEADER\_SIZE macro 197  
ADPCM\_Initialize function 195  
ADPCMHEADER type 197  
AK4954 CODEC Driver Library Help 114  
Audio Demonstrations 8  
Audio Driver Libraries Help 77  
Audio Libraries Help 194  
Audio Overview 2  
audio\_enc 8  
audio\_player\_basic 15  
audio\_signal\_generator 23  
audio\_tone 30  
audio\_tone\_linkeddma 44

### B

Building the Application 13, 20, 26, 40, 63, 74  
Building the Library 84, 121, 163  
Bulding the Application 49

### C

Client Access 79, 116, 159  
Client Operations 79, 116, 159  
Configuring MHC 83, 120  
Configuring the Hardware 13, 21, 27, 41, 50, 64, 74  
Configuring the Library 80, 117, 160  
Configuring MHC 162

### D

Data Types and Constants 203, 205  
DATA\_LENGTH type 109  
Decoder Library Help 194

### Demonstrations

8  
    Audio Demonstrations (audio\_microphone\_loopback) 51  
Digital Audio Basics 2  
Digital Audio in Harmony 5  
drv\_ak4954.h 156  
DRV\_AK4954\_AUDIO\_DATA\_FORMAT type 150  
DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_I2S macro 154  
DRV\_AK4954\_AUDIO\_DATA\_FORMAT\_MACRO macro 117  
DRV\_AK4954\_AUDIO\_SAMPLING\_RATE macro 118  
DRV\_AK4954\_BUFFER\_EVENT type 150  
DRV\_AK4954\_BUFFER\_EVENT\_HANDLER type 150  
DRV\_AK4954\_BUFFER\_HANDLE type 151  
DRV\_AK4954\_BUFFER\_HANDLE\_INVALID macro 154  
DRV\_AK4954\_BufferAddRead function 133  
DRV\_AK4954\_BufferAddWrite function 134  
DRV\_AK4954\_BufferAddWriteRead function 136  
DRV\_AK4954\_BufferEventHandlerSet function 130  
DRV\_AK4954\_CHANNEL type 152  
DRV\_AK4954\_CLIENTS\_NUMBER macro 118  
DRV\_AK4954\_Close function 129  
DRV\_AK4954\_COMMAND\_EVENT\_HANDLER type 152  
DRV\_AK4954\_CommandEventHandlerSet function 132  
drv\_ak4954\_config\_template.h 156  
DRV\_AK4954\_COUNT macro 154  
DRV\_AK4954\_Deinitialize function 126  
DRV\_AK4954\_DIGITAL\_BLOCK\_CONTROL type 153  
DRV\_AK4954\_ENABLE\_MIC\_BIAS macro 118  
DRV\_AK4954\_EnableInitialization function 125  
DRV\_AK4954\_GetI2SDriver function 148  
DRV\_AK4954\_I2C\_DRIVER\_MODULE\_INDEX\_IDXx macro 119  
DRV\_AK4954\_I2S\_DRIVER\_MODULE\_INDEX\_IDXx macro 119  
DRV\_AK4954\_INDEX\_0 macro 155  
DRV\_AK4954\_INDEX\_1 macro 155  
DRV\_AK4954\_INDEX\_2 macro 155  
DRV\_AK4954\_INDEX\_3 macro 155  
DRV\_AK4954\_INDEX\_4 macro 155  
DRV\_AK4954\_INDEX\_5 macro 156  
DRV\_AK4954\_INIT type 153  
DRV\_AK4954\_Initialize function 124  
DRV\_AK4954\_INSTANCES\_NUMBER macro 119  
DRV\_AK4954\_INT\_EXT\_MIC type 153  
DRV\_AK4954\_IntExtMicSet function 144  
DRV\_AK4954\_IsInitializationDelayed function 126  
DRV\_AK4954\_LRCLK\_Sync function 147  
DRV\_AK4954\_MASTER\_MODE macro 119  
DRV\_AK4954\_MIC type 153  
DRV\_AK4954\_MIC\_GAIN macro 119  
DRV\_AK4954\_MicGainGet function 139  
DRV\_AK4954\_MicGainSet function 140  
DRV\_AK4954\_MicMuteOff function 140  
DRV\_AK4954\_MicMuteOn function 141  
DRV\_AK4954\_MicSet function 142  
DRV\_AK4954\_MONO\_STEREO\_MIC type 154  
DRV\_AK4954\_MonoStereoMicSet function 142  
DRV\_AK4954\_MuteOff function 143  
DRV\_AK4954\_MuteOn function 143  
DRV\_AK4954\_Open function 128  
DRV\_AK4954\_ReadQueuePurge function 137

DRV\_AK4954\_SamplingRateGet function 145  
 DRV\_AK4954\_SamplingRateSet function 145  
 DRV\_AK4954\_Status function 127  
 DRV\_AK4954\_Tasks function 128  
 DRV\_AK4954\_VersionGet function 149  
 DRV\_AK4954\_VersionStrGet function 148  
 DRV\_AK4954\_VOLUME macro 120  
 DRV\_AK4954\_VolumeGet function 146  
 DRV\_AK4954\_VolumeSet function 146  
 DRV\_AK4954\_WHICH\_MIC\_INPUT macro 120  
 DRV\_AK4954\_WriteQueuePurge function 138  
 drv\_genericcodec.h 193  
 DRV\_GENERICCODEC\_AUDIO\_DATA\_FORMAT type 193  
 DRV\_GENERICCODEC\_AUDIO\_DATA\_FORMAT\_MACRO macro 160  
 DRV\_GENERICCODEC\_AUDIO\_SAMPLING\_RATE macro 161  
 DRV\_GENERICCODEC\_BUFFER\_EVENT type 188  
 DRV\_GENERICCODEC\_BUFFER\_EVENT\_HANDLER type 188  
 DRV\_GENERICCODEC\_BUFFER\_HANDLE type 189  
 DRV\_GENERICCODEC\_BUFFER\_HANDLE\_INVALID macro 191  
 DRV\_GENERICCODEC\_BufferAddRead function 173  
 DRV\_GENERICCODEC\_BufferAddWrite function 174  
 DRV\_GENERICCODEC\_BufferAddWriteRead function 176  
 DRV\_GENERICCODEC\_BufferEventHandlerSet function 170  
 DRV\_GENERICCODEC\_CHANNEL type 190  
 DRV\_GENERICCODEC\_CLIENTS\_NUMBER macro 161  
 DRV\_GENERICCODEC\_Close function 170  
 DRV\_GENERICCODEC\_COMMAND\_EVENT\_HANDLER type 190  
 DRV\_GENERICCODEC\_CommandEventHandlerSet function 172  
 drv\_genericcodec\_config\_template.h 193  
 DRV\_GENERICCODEC\_COUNT macro 191  
 DRV\_GENERICCODEC\_Deinitialize function 166  
 DRV\_GENERICCODEC\_GetI2SDriver function 187  
 DRV\_GENERICCODEC\_I2C\_DRIVER\_MODULE\_INDEX\_IDXx macro 161  
 DRV\_GENERICCODEC\_I2S\_DRIVER\_MODULE\_INDEX\_IDXx macro 161  
 DRV\_GENERICCODEC\_INDEX\_0 macro 192  
 DRV\_GENERICCODEC\_INDEX\_1 macro 192  
 DRV\_GENERICCODEC\_INDEX\_2 macro 192  
 DRV\_GENERICCODEC\_INDEX\_3 macro 192  
 DRV\_GENERICCODEC\_INDEX\_4 macro 192  
 DRV\_GENERICCODEC\_INDEX\_5 macro 192  
 DRV\_GENERICCODEC\_INIT type 191  
 DRV\_GENERICCODEC\_Initialize function 165  
 DRV\_GENERICCODEC\_INSTANCES\_NUMBER macro 161  
 DRV\_GENERICCODEC\_LRCLK\_Sync function 187  
 DRV\_GENERICCODEC\_MicGainGet function 179  
 DRV\_GENERICCODEC\_MicGainSet function 180  
 DRV\_GENERICCODEC\_MicMuteOff function 180  
 DRV\_GENERICCODEC\_MicMuteOn function 181  
 DRV\_GENERICCODEC\_MuteOff function 182  
 DRV\_GENERICCODEC\_MuteOn function 182  
 DRV\_GENERICCODEC\_Open function 168  
 DRV\_GENERICCODEC\_ReadQueuePurge function 177  
 DRV\_GENERICCODEC\_SamplingRateGet function 183  
 DRV\_GENERICCODEC\_SamplingRateSet function 183  
 DRV\_GENERICCODEC\_Status function 167  
 DRV\_GENERICCODEC\_Tasks function 168  
 DRV\_GENERICCODEC\_VersionGet function 184  
 DRV\_GENERICCODEC\_VersionStrGet function 185  
 DRV\_GENERICCODEC\_VOLUME macro 162  
 DRV\_GENERICCODEC\_VolumeGet function 185  
 DRV\_GENERICCODEC\_VolumeSet function 186  
 DRV\_GENERICCODEC\_WriteQueuePurge function 178  
 drv\_wm8904.h 113  
 DRV\_WM8904\_AUDIO\_DATA\_FORMAT type 109  
 DRV\_WM8904\_AUDIO\_DATA\_FORMAT\_MACRO macro 81  
 DRV\_WM8904\_AUDIO\_SAMPLING\_RATE macro 81  
 DRV\_WM8904\_BUFFER\_EVENT type 109  
 DRV\_WM8904\_BUFFER\_EVENT\_HANDLER type 110  
 DRV\_WM8904\_BUFFER\_HANDLE type 111  
 DRV\_WM8904\_BUFFER\_HANDLE\_INVALID macro 112  
 DRV\_WM8904\_BufferAddRead function 94  
 DRV\_WM8904\_BufferAddWrite function 95  
 DRV\_WM8904\_BufferAddWriteRead function 97  
 DRV\_WM8904\_BufferEventHandlerSet function 91  
 DRV\_WM8904\_CHANNEL type 111  
 DRV\_WM8904\_CLIENTS\_NUMBER macro 81  
 DRV\_WM8904\_Close function 91  
 DRV\_WM8904\_COMMAND\_EVENT\_HANDLER type 111  
 DRV\_WM8904\_CommandEventHandlerSet function 93  
 drv\_wm8904\_config\_template.h 114  
 DRV\_WM8904\_COUNT macro 113  
 DRV\_WM8904\_Deinitialize function 87  
 DRV\_WM8904\_ENABLE\_MIC\_BIAS macro 81  
 DRV\_WM8904\_ENABLE\_MIC\_INPUT macro 82  
 DRV\_WM8904\_GetI2SDriver function 107  
 DRV\_WM8904\_I2C\_DRIVER\_MODULE\_INDEX\_IDXx macro 82  
 DRV\_WM8904\_I2S\_DRIVER\_MODULE\_INDEX\_IDXx macro 82  
 DRV\_WM8904\_INDEX\_0 macro 113  
 DRV\_WM8904\_INIT type 112  
 DRV\_WM8904\_Initialize function 86  
 DRV\_WM8904\_INSTANCES\_NUMBER macro 82  
 DRV\_WM8904\_LRCLK\_Sync function 108  
 DRV\_WM8904\_MASTER\_MODE macro 82  
 DRV\_WM8904\_MicGainGet function 100  
 DRV\_WM8904\_MicGainSet function 101  
 DRV\_WM8904\_MicMuteOff function 101  
 DRV\_WM8904\_MicMuteOn function 102  
 DRV\_WM8904\_MuteOff function 103  
 DRV\_WM8904\_MuteOn function 103  
 DRV\_WM8904\_Open function 90  
 DRV\_WM8904\_ReadQueuePurge function 98  
 DRV\_WM8904\_SamplingRateGet function 104  
 DRV\_WM8904\_SamplingRateSet function 104  
 DRV\_WM8904\_Status function 88  
 DRV\_WM8904\_Tasks function 89  
 DRV\_WM8904\_VersionGet function 107  
 DRV\_WM8904\_VersionStrGet function 108  
 DRV\_WM8904\_VOLUME macro 83  
 DRV\_WM8904\_VolumeGet function 105  
 DRV\_WM8904\_VolumeSet function 106  
 DRV\_WM8904\_WriteQueuePurge function 99

**E**

Encoder Library Help 202

Example Audio Projects 6

WM8904 CODEC Driver Library Help 77

## F

Files 113, 156, 193, 203, 205

## G

GENERIC AUDIO DRIVER CODEC Library 156

## H

How the Library Works 78, 115, 158

## I

Introduction 8, 77, 114, 156, 194, 198, 202, 204

## L

Library Interface 85, 122, 164, 194, 198, 202, 204

Library Overview 78, 115, 157

## M

microphone\_loopback 51

## P

PCM Encoder Library 203

pcm\_enc.h 205

pcm\_encode\_frame function 204

pcm\_encoder\_free function 205

pcm\_encoder\_init function 204

## R

Running the Demonstration 14, 22, 27, 43, 50, 65, 75

    Audio Demonstrations (audio\_microphone\_loopback) 65

## S

SAMPLE\_LENGTH type 154

Setup (Initialization) 78, 115, 158

System Configuration 80, 117, 160

## U

usb\_speaker 67

Using the Library 77, 114, 157, 194, 198, 202, 204

## W

WAV Decoder Library 198

wav\_dec.h 202

WAV\_Decoder function 199

WAV\_GetAudioSize function 200

WAV\_GetBitRate function 200

WAV\_GetChannels function 199

WAV\_GetDuration function 199

WAV\_GetSampleRate function 200

WAV\_HdrGetBytesPerSec function 200

WAV\_HdrGetDataLen function 200

WAV\_HdrGetFileSize function 200

WAV\_HdrGetSamplesPerSec function 200

WAV\_HEADER\_SIZE macro 201

WAV\_HEAP\_SIZE macro 201

WAV\_Initialize\_N function 199

WAV\_UpdatePlaytime function 199

WAVE\_FORMAT\_ALAW macro 201

WAVE\_FORMAT\_MULAW macro 201

WAVE\_FORMAT\_PCM macro 201