Renesas Synergy™ Platform

Getting Started with the Audio Player Application using SSP

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Introduction

This application note describes the Audio Player demonstration application for Renesas Synergy™ S7G2 MCU based kits. Audio Player is a Human Machine Interface (HMI) application that uses Synergy Software Package (SSP) with GUIX™, USBX™, and FileX™. The program consists of a simple file browser with audio playback capabilities. The interface employs several GUIX widgets and touch controls to manage the underlying Audio Playback Framework and Mass Storage Controller (MSC).

Audio Player is based on SSP and uses Express Logic, Inc. ThreadX® Real-Time Operating System (RTOS), GUIX, USB, and FileX through the e² studio Integrated Solutions Development Environment (ISDE) or IAR Embedded Workbench for Synergy. The application code and configuration can be used as a reference for event-driven HMI and MSC systems. The program includes code based on GUIX and the SSP for fast graphics rendering and display, and uses the graphics accelerators available on the S7G2 devices. Additionally, it implements USBX and FileX to allow it to access data on FAT-formatted USB Mass Storage Devices.

Required Resources

- Any of the following kits
  - Renesas Synergy SK-S7G2 Starter Kit (currently supported)
  - Renesas Synergy DK-S7G2 Development Kit
  - Renesas Synergy PE-HMI1 Product Example for HMI applications
  - Renesas Synergy PK-S5D9 Promotional Kit
- e² studio ISDE v6.2.1 or later
- Synergy Software Package (SSP) 1.5.0 or later
- IAR EW 8.23.1 or later
- SSC v6.2.1 or later
- SEGGER J-link® USB driver
- Micro USB cables
- USB 2.0 Flash drive

Download all the required Renesas software from the Renesas Synergy™ Software page at https://synergygallery.renesas.com.

Supported File Formats

Audio Player application is compatible with uncompressed WAVE files in PCM format. Make sure that the audio stream is signed mono with 16 bits per sample and sampling frequency of 44.1 kHz. Audio Player will prevent incompatible files from playing and produce a warning message that is visible on a status bar.

Contents

1. Supported Boards and Files

The Audio Player demonstration application using the Audio Playback Framework supports all versions of the S7G2 boards and the PK-S5D9 board. Files supported for playback are mono, signed, 16-bit sample, 44.1 kHz PCM streams stored in a WAVE file format. Creating compatible files is explained in section 3.4, Compatible Audio Formats.

2. Running the Audio Player Application

2.1 Connecting to the Board and Importing the Project into e^2 studio

This section describes how to connect the board to power, the J-Link debugger to the PC, and the board to the PC.

More information can be obtained as follows:

- To set up the power connection and the J-Link debugger connection from your PC to the JTAG connector on the target board, refer to the S7G2 Starter Kit (SK-S7G2) Quick Start Guide, S7G2 Development Kit (DK-S7G2) Quick Start Guide HMI Product Example (PE-HMI) Quick Start Guide or S5D9 Promotional Kit(PK-S5D9)Quick Start Guide.
- For instructions on importing the project into e^2 studio and building/running the application, refer to the Synergy Project Import Guide (r11an0023eu0120_synergy_ssp.pdf, included in this package).

2.2 Running and Verifying the Application

- Before running the application, copy the audio files (bundled as part of the project) to the USB Flash drive and connect to the USB Host connector of the board.
- You will see the Splash screen on bootup. If the USB drive with the audio files to be copied to is inserted, names of the audio files will be displayed on the LCD screen. Select the audio file for playing and press the play button. Detailed screen operation is explained in the section 3.
- For boards which do not have the in-built speaker, connect the head phones.
- **On DK-S7G2**, verify that switch array S5 is configured to enable JTAG, PBs, and SDRAM.
- The audio quality varies based on the audio speaker connected. The quality is better when it is played using audio headphones

3. Application Features

3.1 Splash Screen

You will see the GUIX-rendered splash screen just after you start the program. After several seconds, the screen changes to the next screen (determined by presence of the USB mass storage device).

Figure 1 Splash Screen (for PK-S5D9/SK-S7, DK-S7/PE-HMI1)

3.2 USB Screen

The USB screen is displayed when the USB mass storage device is not detected. Certain devices are recognized fast enough for the application to skip this screen and jump straight to the main screen. Others will require additional time to fully initialize before being recognized by the Synergy board. It will also be displayed when no mass storage devices are plugged in.

Figure 2 USB Screen (top-left: SK-S7/PK-S5D9, top-right: DK-S7, bottom: PE-HMI1)

3.3 Main Screen

3.3.1 Overview

The main audio player screen appears once a USB mass storage device has been detected. This window consists of a status bar, file browser, and 3 buttons (5 buttons on PE-HMI1). The interface dynamically adjusts to reflect the current playback status and provide necessary functionality. The file browser allows the user to explore the file system and open PCM WAVE files for playback.

All screen contents are rendered by D/AVE2D drawing engine and are displayed on the TFT screen connected to the Graphic LCD Controller.

Figure 3 Main Screen (from the top: SK-S7/PK-S5D9, DK-S7, and PE-HMI1)

3.3.2 Playback Controls

The Graphical User Interface (GUI) behaves differently for each playback status. This allows screen space to be re-used in order to provide complete audio player functionality.

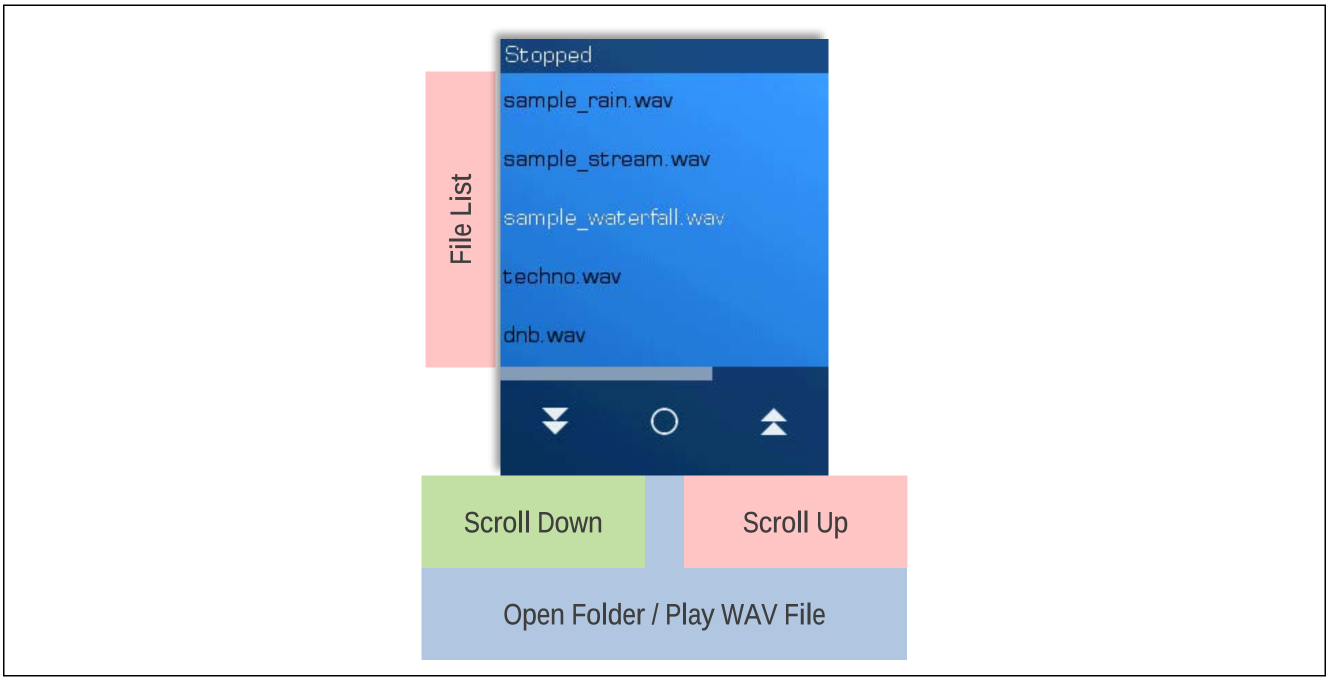


Figure 4 Main Screen (1) GUI While Playback is Stopped

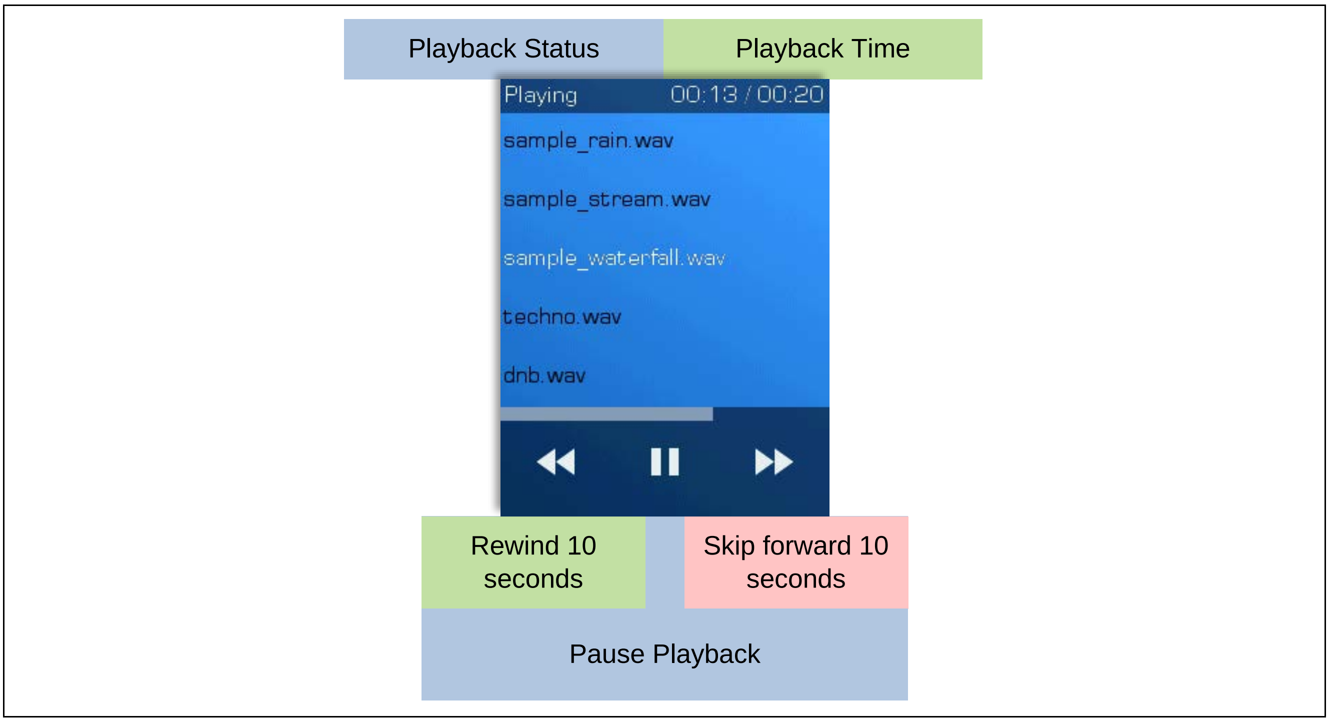


Figure 5 Main Screen (2) GUI When Audio is Playing

Figure 6 Main Screen (3) GUI When Playback is Paused

Figure 7 Main Screen on PE-HMI1 with On-screen Volume Controls

Due to limited screen space, the application uses two on-board pushbuttons (S5 and S4 on SK-S7/PK-S5D9, S2 and S3 on DK-S7) for playback volume control (down and up, respectively). PE-HMI1 version of the application implements on-screen volume controls due to lack of on-board pushbuttons.

3.4 Compatible Audio Formats

The audio player application will stop any playback and take the user back to the USB Screen if the USB device is removed. RIFF header recognition allows the program to prevent playback of incompatible WAV files. In order to play music on your Renesas Synergy™ S7G2 board, make sure that the USB mass storage device is formatted to FAT16/32 and the WAVE audio files are uncompressed (PCM), signed, 16-bit per sample, mono, 44.1-kHz streams. Status bar will display an error message once incompatible file attempts playback. Compatible audio files can be created from most input formats using the ffmpeg codec with the following command:

```
ffmpeg -i %infile% -acodec pcm_s16le -ac 1 -ar 44100 %outfile%
```

4. Application Design

4.1 Source Code Layout

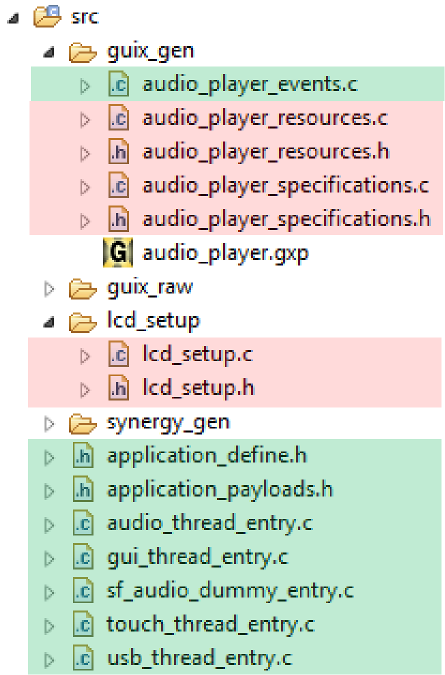
Application code for Audio Player is split between four thread entry files as well as the GUIX Event Handler and a custom application-defined header file and payload definition file. This creates robust building blocks that can easily be ported into another application (if the configuration for the thread and its modules is also copied).

User-created source files:

- application_define.h
- application_payloads.h
- audio_thread_entry.c
- gui_thread_entry.c
- touch_thread_entry.c
- usb_thread_entry.c
- sf_audio_dummy_entry.c
- guix_gen/audio_player_events.c

User-generated or referenced source files:

- audio_player_specifications.c/.h
- audio_player_resources.c/.h
- lcd_setup/lcd_setup.c/.h (only on SK-S7/PK-S5D9)



4.2 Thread Layout

4.2.1 Module Hierarchy

Figure 8 illustrates the hierarchy and dependency of the modules belonging to each thread. Conventional design implements GUI and Touch functionality on the same thread (usually called HMI). The Audio Player application separates the two to emphasize independency between touch and display peripherals, and to provide separate subscriber threads for touch and callback messages, both of which are converted and forwarded to GUIX.

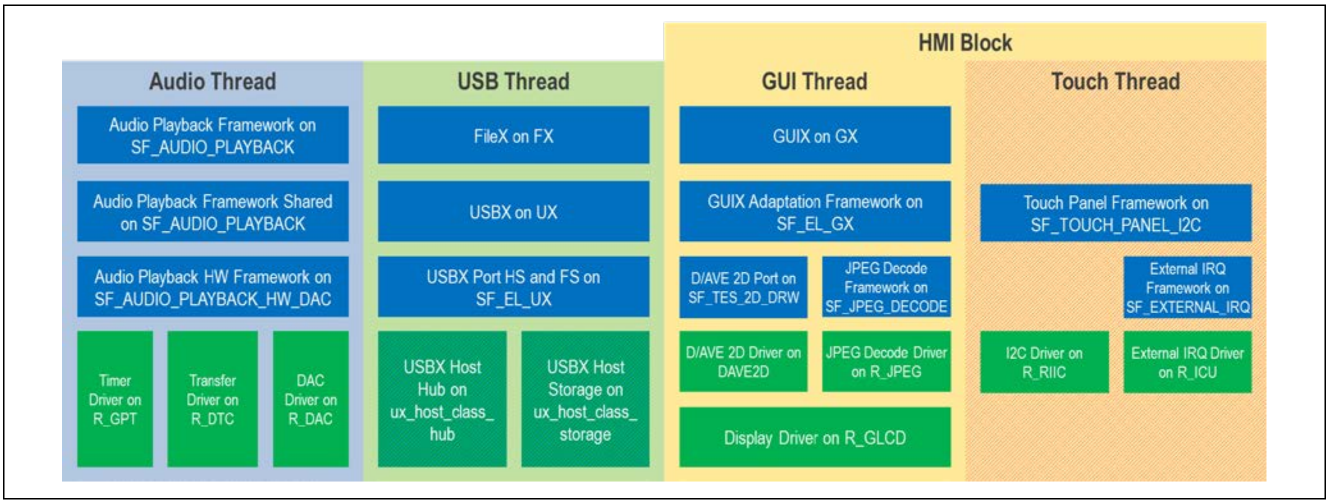


Figure 8 Module Hierarchy

4.2.2 Thread Modules and Objects

In addition to core module blocks visible on the previous diagram, the Audio Player application employs additional ThreadX objects such as queues and semaphores. These objects enable communication between threads and control the code execution without blocking the processor.

4.3 Thread Initialization

Even though different functionalities are isolated into separate threads, minimal dependency between each thread is still present. When launching the application, make sure that modules, objects, and variables that are not initialized yet are not accessed from another thread. Fundamental functionality (Mass Storage Controller and Audio Thread) must be initialized before proceeding to enable GUI and other HMI features (Touch). Audio Player using Audio Playback Framework launches its threads in the order shown in Figure 9.

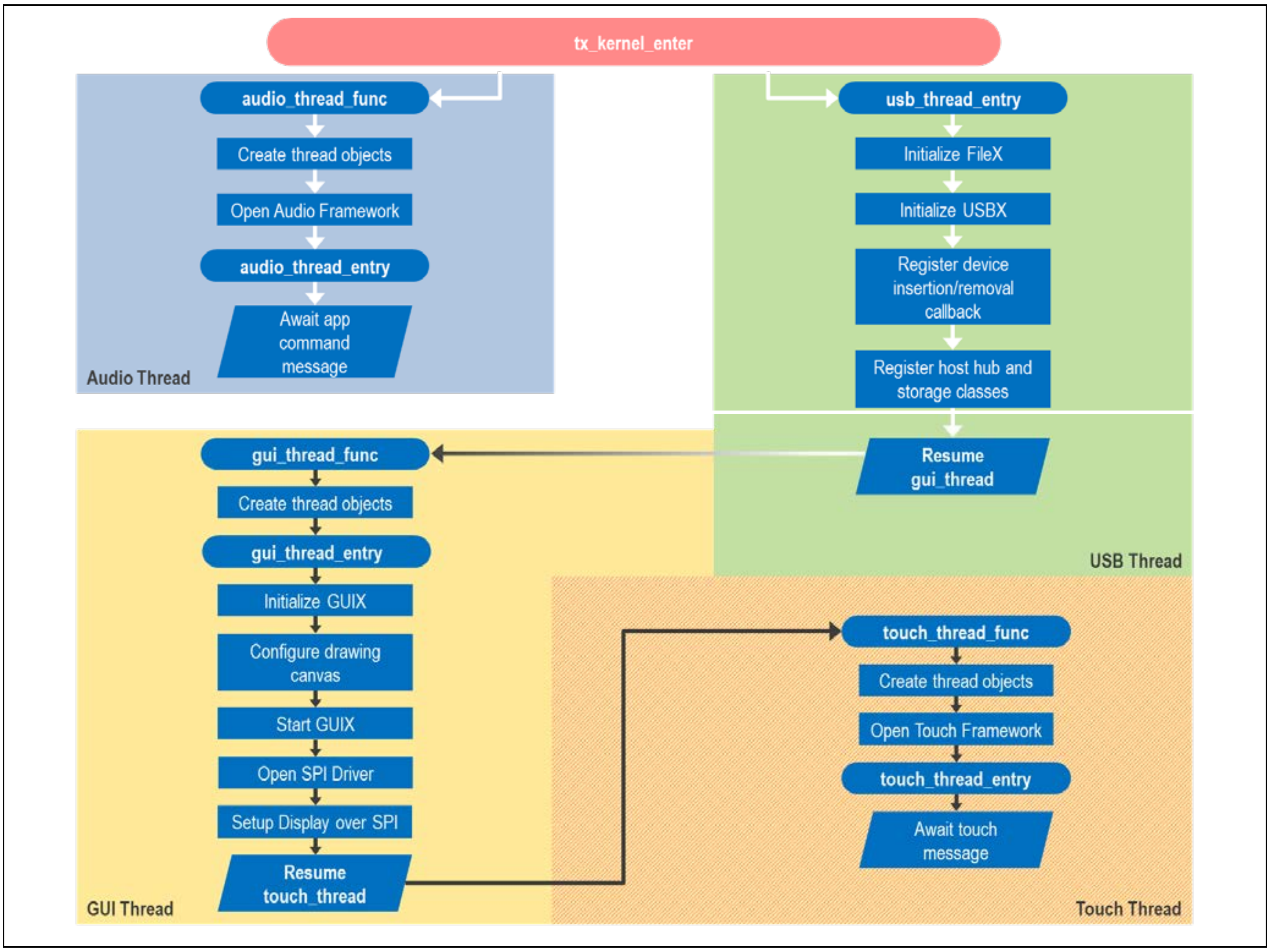


Figure 9 Thread Initialization Order

4.4 Thread Resources

4.4.1 Static Variables

- usb_thread_entry.c
  - Storage instance in **gp_storage*
  - Media pointer in **gp_storage_media*
  - USB host stack in *g_usb_memory*
- audio_thread_entry.c
  - 2 read buffers in *g_file_buffer*[2]
  - Buffered data size in *g_acutal_size*[2]
  - Index of accessed buffer in *g_current_buffer*
- audio_player_events.c
  - Directory file list in *g_file_list*
  - Index of the selected list entry in *g_file_list_index*

4.4.2 Global Variables

- Media Storage pointer in **gp_media*
  - Declared in usb_thread_entry scope
  - Accessed from audio_thread_entry scope
- Audio file RIFF header in *g_file_info* and audio player status in *g_player_status*
  - Declared in audio_thread_entry scope
  - Accessed from audio_player_events scope
- Root window pointer in **p_window_root*
  - Declared in gui_thread_entry scope
  - Accessed from audio_player_events scope

4.5 Inter-thread Communication

The messaging framework is the core module responsible for communication between threads. It provides a thread-safe way of sharing variables that is built on top of the ThreadX Queue module. It expands the basic functionality by providing a unified scheme for message format that includes its class, code, and payload. Since queues are only used to pass a pointer to the message, the actual message size can be greatly increased to accommodate custom payload structure. The Audio Player application uses four different message classes:

- SSP-defined: *TOUCH* and *AUDIO*
- Application-defined: *APP_CMD* and *APP_CB* (application command and callback, respectively)
- Command messages (APP_ prefix):
  - Posted from GUIX Event Thread and pushbutton interrupt callback function
  - Received and parsed by Audio Thread
- Callback messages (APP_CB and APP_ERR prefixes):
  - Posted from Audio and USB Threads
  - Received by GUI Thread and forwarded to GUIX Event Thread as GX_EVENT

Figure 10 Command and Callback Messages

4.5.1 Command Messages

All command messages in the Audio Player application are processed by the Audio Thread. They lead to a sequence of FileX and SF_MESSAGE API calls in order to control playback and data flow into the internal Audio Framework Thread. The messages can be sent from any thread, allowing the user to replace the GUI with a different interface while retaining full audio playback control capabilities as the underlying USB and Audio Threads are not affected.

Most commands use a payload structure to provide additional data such as the name of the file to be opened or the step size for volume change. Successful execution of the command generates a callback message, which is fed back into the GUIX Event Thread to update status of the interface or display an on-screen message.

4.5.2 Callback Messages

The Audio Thread also posts callback messages to report completion of the task (or an error, if encountered). As the majority of commands are posted from the GUIX Event Thread, the callback messages are routed into the GUIX Event Thread for the GUI to reflect the Audio Thread status (by adjusting the interface and displaying messages).

Every status change generates a callback message. Therefore, the GUI does not have to check global variables regularly. Instead, it only needs to acquire status upon receiving a message. All callback messages are interpreted into GX_EVENTs so that they are handled within the window event process, along with other GUI events such as touchscreen input. When an error callback is posted, the message payload carries a return value from the function that failed to execute.

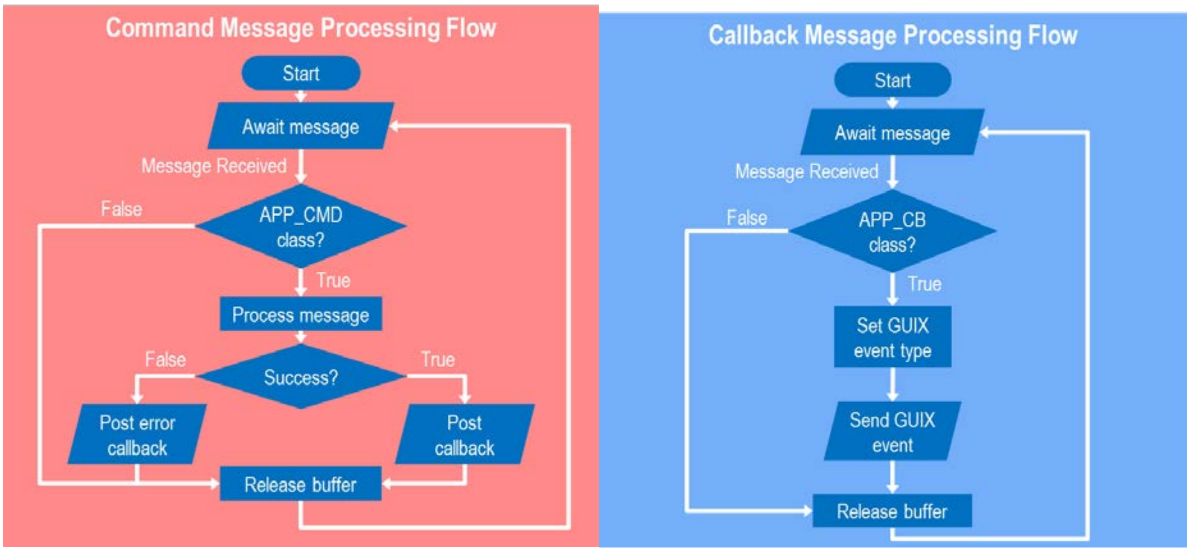


Figure 11 Message Flow

4.6 Message Processing Flow Example

Figure 12 shows an example of the steps taken to process an “open” command and generate callback upon successful completion of the task. Note that the flowchart is simplified and focuses on illustrating message flow between the threads rather than step-by-step execution sequence.

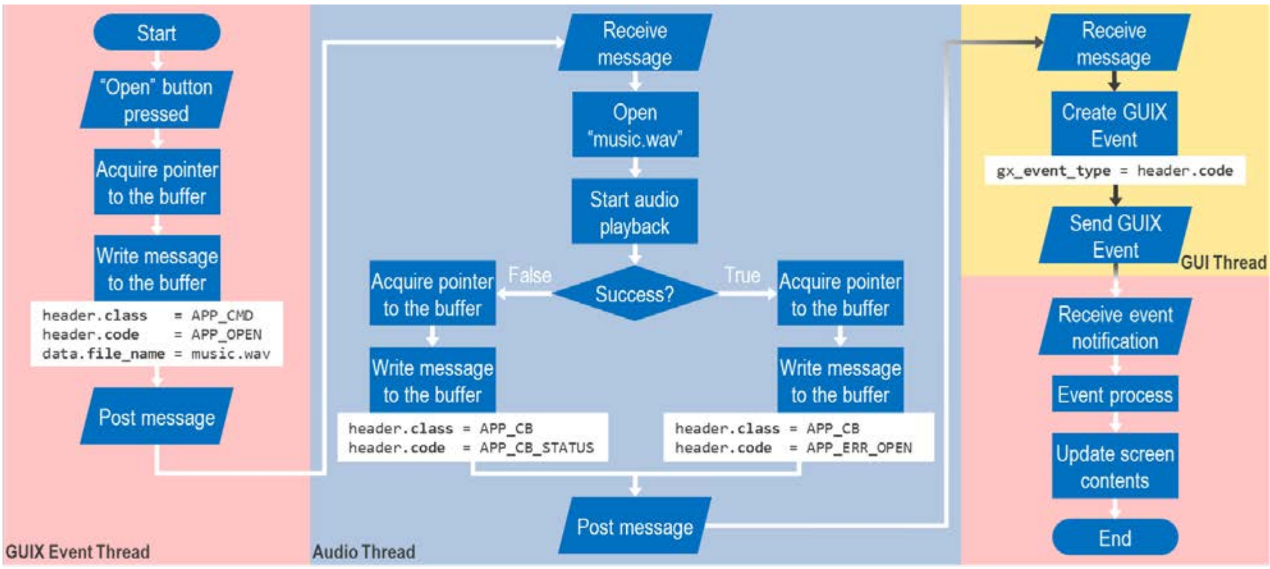


Figure 12 Message Processing Example

For more detail on audio thread processing, see the section 4.7.

4.7 Audio Thread Processing Flow

Audio Thread implements the Audio Playback Framework, creating the foundation of this application. It is fully controlled using the messaging framework. Since messages can be sent and received by any thread, the graphical user interface (GUI) of this application can easily be replaced with an alternative input/output media such as USB CDC AMC device (using USBX), telnet console, or a remote website (both using NetX).

Ping-pong buffering is used to preload audio data while maintaining seamless playback and GUI responsiveness. Buffer size is set to 8 KB, which is enough to store about 90 ms of the 16-bit PCM mono stream.

The thread runs in a permanent loop, first awaiting the message for a single ThreadX tick (default value: 10 ms) before generating timeout and resuming with playback processing. Here, player status is verified (to be *PLAYING*) before the thread attempts to push another set of samples into the buffer. A counting semaphore determines whether the contents of the buffer have been played. When playback is *PAUSED* or *STOPPED*, or semaphore count is zero, the thread hands off processor control to other threads before restarting the loop to await another message.

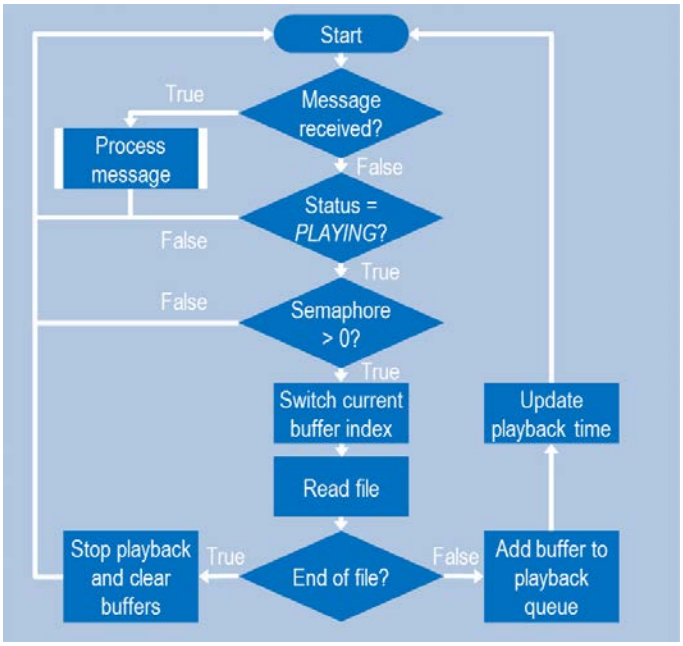


Figure 13 Audio Thread Processing Flow

4.8 GUI Structure

The graphical user interface (GUI) is the primary input and output media for this application. The GUI is split into three screens: splash, USB, and main. Content windows are embedded into, and displayed over their background parent window to allow independent control of the background and overlay pixel maps. Events for all widgets (such as buttons and text labels) are handled by the event process of their parent window.

Audio Player application uses 16 alpha-enabled pixel maps and two 8-bit fonts to provide a smooth GUI experience. These resources add up to just under 440 kB, leaving plenty of room in flash memory for alternative themes and additional features.

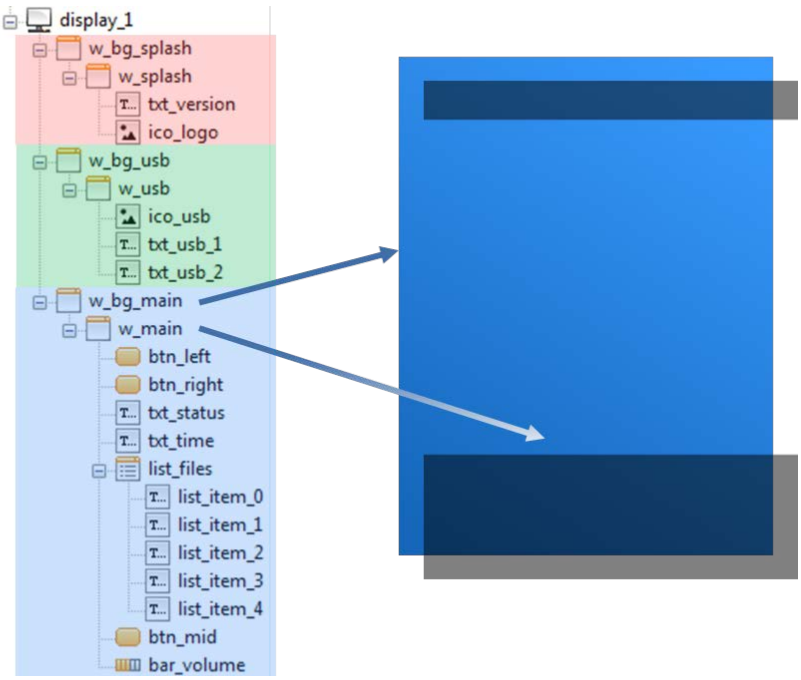


Figure 14 GUI Structure

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jun 21, 2016	-	Initial version.
1.01	Nov 18, 2016	Title	Minor formatting changes.
1.02	Oct 11, 2018	All	Updated for SSP v1.5.0

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