EAP in the RT600 SDK

Application Note

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Change History

Version	Status	Description	Author	Date
1.0	Proposed	Initial	Christophe Boulant	2020/04/08
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1.2	Reviewed	Add RT600 platform integration information	Tomas Barak	2020/04/09

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1 DOCUMENT DESCRIPTION

1.1 Purpose

This document presents the Essential Audio Processing package elements available in NXP RT600 SDK.

1.2 Overview

The EAP SDK part is coming with:

- An EAP user guide
- A pre-compiled library for RT600
- A tuning tool simulator for windows
- An EAP integration example based on XTENSA RT600 simulation
- An EAP integration example based on a hardware RT600 platform integration

1.2.1 What to do with this EAP package?

Learn about the EAP feature and EAP tuning capability for each processing block:

- Read the EAP user guide.
- Parse the parameter text file preset (or C code header preset).

Evaluate EAP and play with the parameters on a PC (no hardware required):

- Read Tuning tool simulator chapter.
- Install the EAP tuning tool simulator on your PC.
- Run and listen demo.
- Select a parameter preset (text file) and apply it to the soundtrack of your choice.
- Listen and compare the results thanks to the EAP tuning tool simulator.

Learn about the integration of the EAP library:

- Read the EAP user guide.
- Parse or Run the EAP integration example based on XTENSA RT600 simulation.
  Full EAP API is used as example.
- Parse or Run the EAP integration example based on a hardware RT600 platform integration.
  Essential EAP API is used.

Enjoy the EAP on the EAP SDK board

- Run the EAP integration example based on a hardware RT600 platform integration.
- Select a parameter preset with the Uart command.
- Update the custom preset (header file) based on your requirements.
- Recompile and listen to the results.
- Compare with original file.

1.3 EAP User guide

The EAP user guide (EAP_userGuide.pdf) provides information to understand, tune and integrate the Essential Audio Processing solution in your product.

For each processing block, it provides:

- A description of the behavior.
- A description of the tuning parameters to perform classic tuning.

An additional chapter explains how to perform the integration.

1.4 Tuning tool simulator

The tuning tool simulator permits to simulate the EAP library processing behavior on a Windows PC platform. It uses:

- A pre-compiled executable
- A preset configuration file (text file)

Simulator provide same output audio file (bit exactness) than the library and can be used to find the right tuning parameter setting.

It also provides:

- A player to listen and compare A/B files.
- A tool to generate a C code header parameter file based on a text parameter file

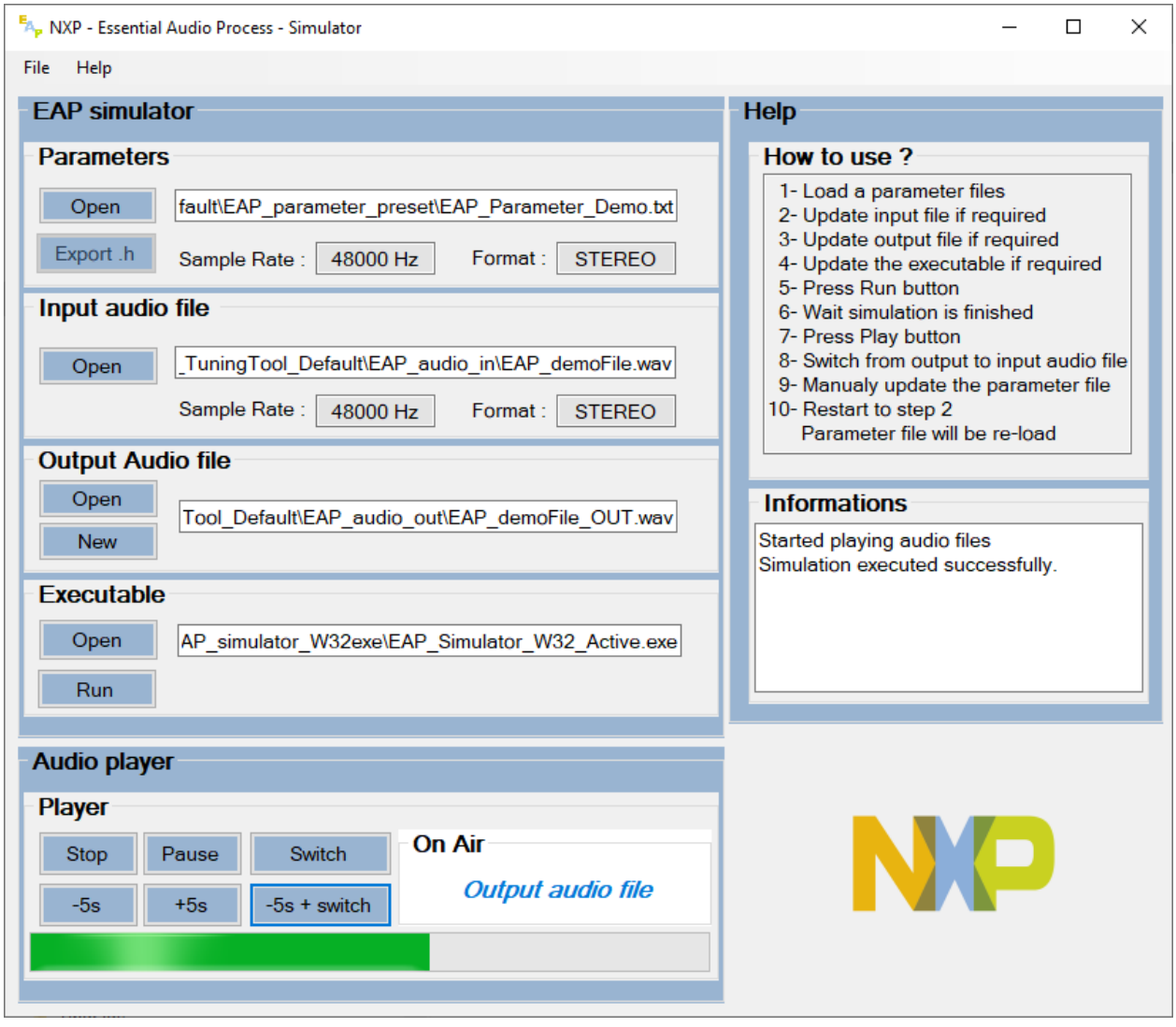

Figure 1 NXP EAP tuning tool - simulator

Note: The preset configuration file used by the simulator is a text file. It doesn't include headroom parameters setting which are pre-compiled in the simulator exe.

The preset configuration file used by the library is a C code header file. It includes headroom parameters configuration.

Both files have different formats and must reflect the same EAP parameters configuration to provide bit exact output audio file.

For more details about the headroom parameters refer to the EAP user guide.

1.5 Audio preset

The EAP package is coming with audio preset parameters.

- Audio preset test file (.txt) is dedicated to windows tuning tool simulator.
- Audio preset header file (.h) is dedicated to C code.

User can modify them manually with the help of the comments included in the preset file and the EAP user guide.

Audio tuning is an important point and must be considered to obtain great audio behavior. It permits to adapt the EAP processing feature to the product elements:

- the audio chains.
- the speakers.
- the casing of the speaker.

The preset effect can't be optimal for your design but are a good start of point.

1.5.1 AllEffectOff

All Effect are off.

Only volume control and balance are applied.

1.5.2 VoiceEnhancer

Equalizer with 3 bands are set to enhance voice frequency part.

Loudness maximiser with 2dB gain in Gentle mode is used.

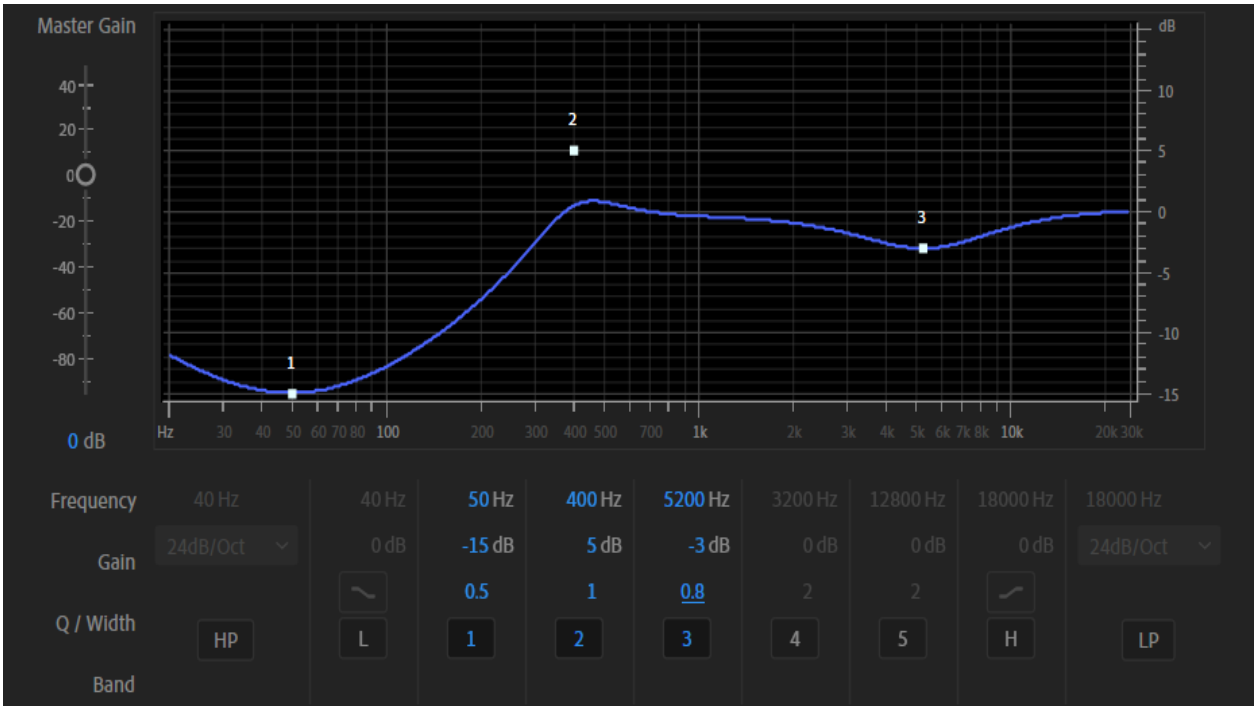

Figure 2 Voice parametric 3 bands equalizer curve (from adobe audition)

Effect:

- Voices are more present
- Soundtrack is less muffled

1.5.3 MusicEnhancer

Equalizer with 4 bands are set to increase frequency part up to 1KHz.
Treble enhancer with 4dB gain curve is used to boost the high frequency
Dynamic bass enhancer is added to increase bass dynamically. (G=9dB, Fcenter=90Hz)

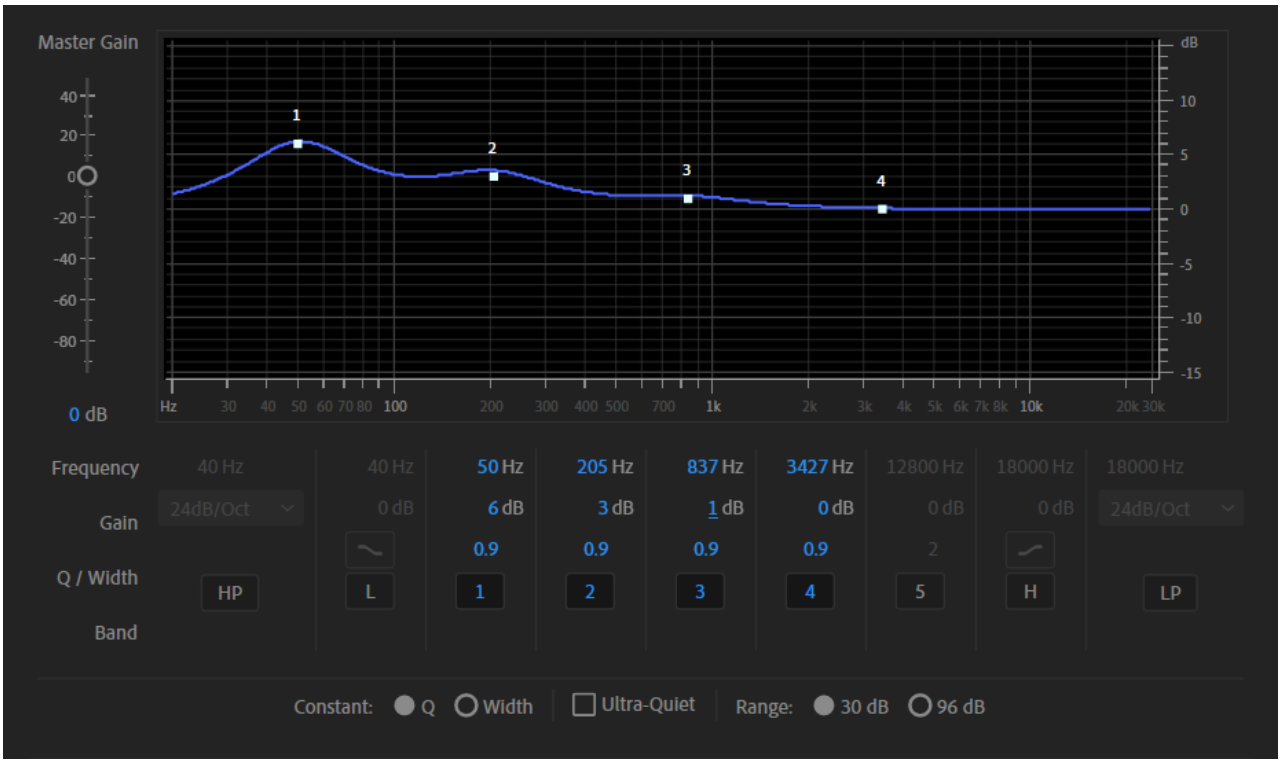

Figure 3 Music parametric 4 bands equalizer curve (from adobe audition)

Effect:

- Bass frequencies are more present and deeper
- Treble frequencies are more present.

1.5.4 AutoVolumeLeveler

Auto volume leveler is turned On.
High pass filter of the dynamic bass enhancer is used to avoid any residual DC offset.
Volume parameter (VC_EffectLevel) is set to -9dB.
Effect:

- Volume between soundtracks is constant
- Low volume part of a soundtrack is boosted

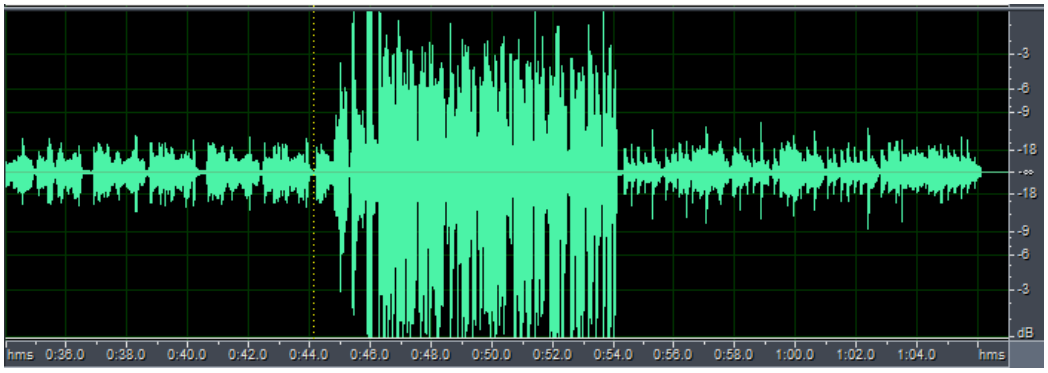

Figure 4 Input audio file

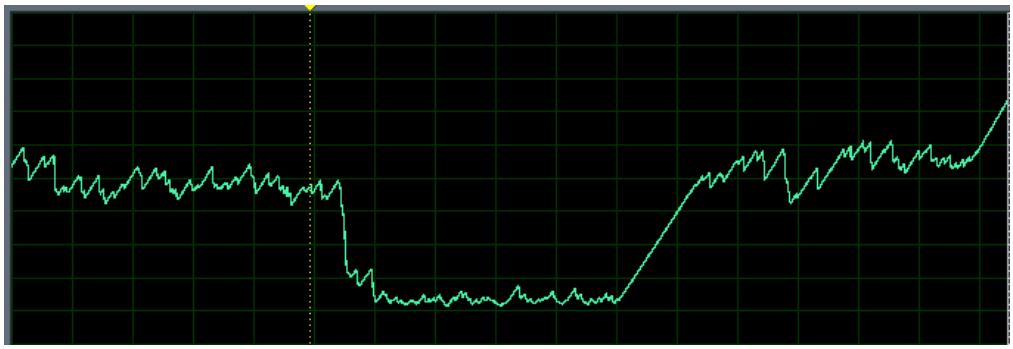

Figure 5 Input audio file AVL gain applied (see Read AVL Gain API chapter)

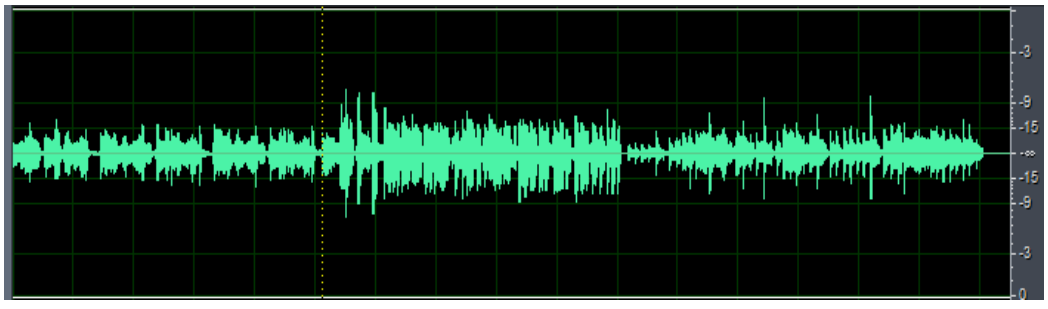

Figure 6 Output audio file

1.5.5 ConcertSound

3D Virtualizer is turned ON and the virtualizer type is set to concertSound.

Effect:

- Music appears more distant
- Some reverberation is present and provide large room feeling

Note: According the module (cinema sound (CI) or concert sound(CS)) of the 3D Virtualizer selected at compilation, effects (CONCERTSOUND, MUSIC or MOVIE) are available or not (see EAP user guide).

1.5.6 LoudnessMaximiser

Volume control is set to -3dB.

Loudness maximiser with 6dB gain in Medium mode is used.

Effect:

- Volume boost of 6dB apply to the soundtrack whereas peaks values stay the same
- Get the maximum sound level of a speaker without damage it. It is generally used with small speakers.

1.5.7 Custom

Equalizer with 4 bands are set to increase frequency part up to 6KHz.

Treble enhancer with 9dB gain curve is used to boost the high frequency

Dynamic bass enhancer is added to increase bass dynamically. (G=6dB, Fcenter=55Hz)

3D Virtualizer is turn ON and the type is set to concertSound.

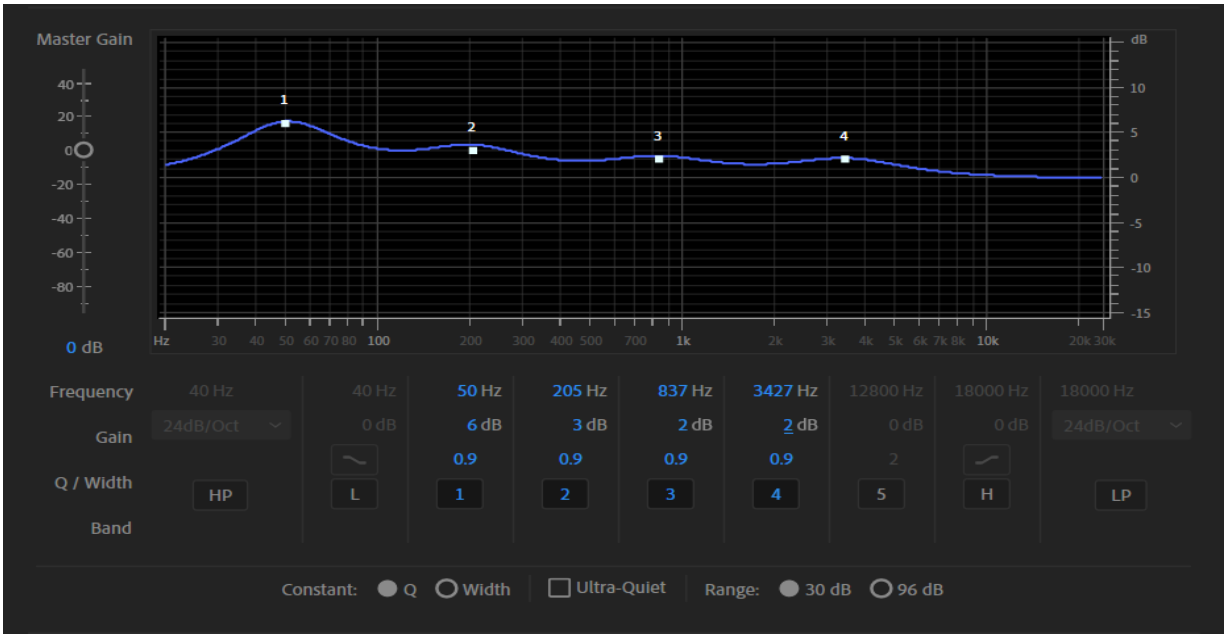

Figure 7 Music parametric 4 bands equalizer curve (from adobe audition)

Note: In the example based on the RT600 platform integration, the custom setting is your setting. Don't hesitate to modify it to adapt to your hardware.

1.5.8 Tone Generator

Not available in the example based on a hardware RT600 platform integration.

Sweep tone generator is turned On:

- 1 shot of 10seconds.
- Sweep linear mode

Other processing block are turned off.

Effect:

- At the beginning of the process, a sweep tone generator of 10 seconds is generated
  It is a tone starting from 20Hz to 22KHz.
  The start amplitude is -12dB
  The stop amplitude is -3dB
  It permits to execute some measures. Per example, measure of the spectral response of the speaker.

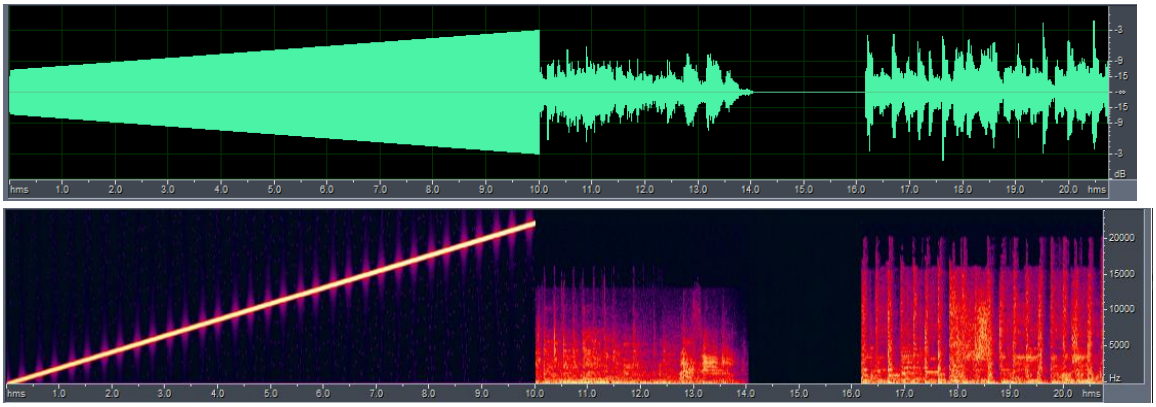

Figure 8 Sweep Tone Temporal & Spectrum (from adobe audition)

Note: Take care to keep low amplitude sweep tone to not damage your speaker.

1.5.9 AllTestOn

Not available in the example based on a hardware RT600 platform integration.

All processing block are turned On.

This parameters configuration doesn't deliver a great audio output and mustn't be use for that. Audio output is not relevant.

It is reserved for test and measures:

- MIPS
- Memory
- Bit exactness test

1.6 Pre-compiled library

According to the compilation symbol option, a selection of the processing blocks is available in the library.

When programmer include this library, he must declare the same symbol definition in his project.

1.6.1 Lib Version 1.0.0

Library name : libEAP_Lib_1_0_0_RT600ReleaseO3_CS_DBE_EQNB_LM_AVL_TE_VC_TG_PSA

Library version : libEAP_Lib_1_0_0

+

Platform: nxp_rt600_RI2019_newLib

Compilation Symbol: DLVCS_MS_COEFFS_SMALL=1 -DALGORITHM_CS=1 -DALGORITHM_DBE=1 -DALGORITHM_EQNB=1 -DALGORITHM_LM=1 -DALGORITHM_TE=1 -DALGORITHM_TG=1 -DALGORITHM_AVL=1 -DALGORITHM_PSA=1 -DALGORITHM_VC=1.

Optimization level: O3

This EAP library has been compiled with following algorithm available:

- Volume and balance control (VC)
- Concert sound (CS)
- Digital Bass enhancement (DBE)
- Treble effect (TE)
- Equalizer (EQNB)
- Loudness maximizer (LM)
- Auto Volume Level (AVL)
- Power spectrum analyzer (PSA)
- Tone generator (TG)

This EAP library do not include following algorithm.

- Pure bass (PB) because concurrent with DBE
- Cinema sound (CI) because concurrent with CS
- Richsound (RS) because obsolete
- GentleMixer (GM) because obsolete

1.7 EAP integration example based on XTENSA RT600 simulation

Xtensa EAP example application project is using the entire EAP library API.

It shows how to:

- Initialize the EAP library
  - Get EAP library memory requirement
  - Create an instance of the EAP library
- Set a preset parameter
- Update a parameter
- Volume update with no smoothing
- Get the Power Spectrum Analysis
- Set the custom advanced parameters
- Get the current AVL gain

1.7.1 Initialize the EAP library

Parse the TEST_PARAMS.c code as an example.

1.7.2 Set a preset parameters

Parse the TEST_PARAMS.c code as an example.

A define permits to choose which preset to apply at initialization.

- EAP_PARAM_ALL_EFFECT_OFF
- EAP_PARAM_VOICE_ENHANCER
- EAP_PARAM_MUSIC_ENHANCER
- EAP_PARAM_AUTO_VOLUME_LEVELER
- EAP_PARAM_CONCERTSOUND
- EAP_PARAM_LOUDNESS_MAXIMISER
- EAP_PARAM_TONE_GENERATOR
- EAP_PARAM_CUSTOM
- EAP_PARAM_TEST_ALL_ON

1.7.3 Update a parameter

This example shows how to update one or multiple EAP parameters.

Parse the TEST_PARAMS.c code as an example with EXAMPLE_PARAMETER_UPDATE defined.

1.7.4 Volume update no smoothing

When volume parameter (VC_EffectLevel) is updated, a volume smoothing between old and new volume is applied to avoid volume gap artifact.

This example shows how to update volume parameter without any smoothing.

Parse the TEST_PARAMS.c code as an example with EXAMPLE_VOLUME_UPDATE_NO_SMOOTHING defined.

1.7.5 Power Spectrum Analysis

Parse the TEST_PARAMS.c code as an example and focus on section code defined by ALGORITHM_PSA.

This example read the PSA and write the value in a .dat files.

1.7.6 Custom advanced tuning

The custom advanced tuning are additional advanced parameters. They allow the customer to define a particular taste for speaker equalization, speaker virtualization and headphone virtualization.

Where no such tuning requirements exist, the default tuning values can be used and the GetCustomTuning and SetCustomTuning parameter functions can be ignored.

Parse the TEST_PARAMS.c code as an example with EXAMPLE_CUSTOM_TUNING defined.

1.7.7 Read AVL Gain

API permits to read the gain used by the Auto Volume Leveler.

Parse the TEST_PARAMS.c code as an example with EXAMPLE_AVL_READ_GAIN defined.

In this example the gain is duplicated to fill a full frame size and is written as it is a pcm file. It permits to analyse the AVL behavior (see Read AVL Gain chapter).

1.8 EAP integration example based on a hardware RT600 platform integration

This EAP integration example :

- Runs on a RT600 hardware board.
- Provides full audio solution based on Xtensa Audio Framework
- Shows essential EAP library integration requirements
  (for full API example refer to EAP integration example based on XTENSA RT600 simulation)
- Permits to select EAP preset parameters
- Permits to increase or decrease EAP volume parameter
- Permits to control left/right audio EAP balance parameter

1.8.1 Control the EAP preset parameters

A UART command permits to:

- select an EAP preset parameters
- increase or decrease EAP volume parameter
- control left/right audio EAP balance parameter

Others EAP parameters are not accessible to the Uart command and need header file update + project re-compilation.

A custom preset parameter (EAP_Parameter_Custom.h) is dedicated for the user parameters and can be updated.

A simple command explanation is displayed in the application using command ‘help’ in the shell. For further information, a readme.txt attached to the example application is present.

ABBREVIATIONS AND REFERENCES

Abbreviations	
API	Application Programmers Interface
AVL	Auto Volume Leveler
BE	Bass Enhancement, either PureBass or DBE which ever is included in the bundle release
Block Size	Equal Frame Size
Buffer Size	The size of a buffer in Bytes. For a mono stream this the Block Size times the size of one sample in Bytes, for a stereo stream this is twice the Block Size times the size of one sample in Bytes.
CS	ConcertSound, 3D widening
DBE	Dynamic Bass Enhancement
dBFS	dB relative to full scale signal
EQNB	N-Band Equalizer
Frame Duration	The duration of a buffer of samples in seconds. This is given by the Frame Size divided by the Sample Rate.
Frame Size	The number of samples per channel to be processed in one call to the LVM_Process function.
Inplace	The name for processing data where the input and output buffers are at the same physical address in memory
Interleaved	The arrangement of samples in memory where the samples are alternately for the Left channel and the Right channel
LM	Loudness Maximiser
MIPS	Million Instructions Per Seconds
Non-Interleaved	The arrangement of samples in memory where the samples for each channel follow one another,
Nyquist	Half the sample rate
Outplace	The name for processing data where the input and output buffers are at different physical addresses in memory
PB	PureBass
PSA	Parametric Spectrum Analyzer.
Sample Rate	The number of samples per second.
TE	Treble Enhancement
TG	Tone Generator
VC	Volume control

References	
EAP user guide	*EAP_UserGuide.pdf*