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# **Hifi4 DSP User's Guide**

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# Table of Contents

<b>1</b>	<b>Introduction .....</b>	<b>3</b>
<b>2</b>	<b>System Architecture .....</b>	<b>4</b>
<b>3</b>	<b>File Organization.....</b>	<b>5</b>
3.1	Hifi4 driver .....	5
3.2	Hifi4 framework .....	5
3.3	Hifi4 wrapper and unit test .....	5
3.4	Interface header files .....	5
<b>4</b>	<b>Hifi4 toolchain setup .....</b>	<b>6</b>
4.1	Xtensa development toolchain .....	6
4.2	Linaro compiler toolchain .....	7
<b>5</b>	<b>Usage of Hifi4 binary files .....</b>	<b>8</b>
5.1	Get Hifi4 binary files.....	8
5.2	Binary files in linux rootfs .....	8
5.3	Unit test and playing .....	9
<b>6</b>	<b>Memory allocation for Hifi4.....</b>	<b>10</b>

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# 1 Introduction

This document is the overall introduction of hifi4 dsp, include system architecture, file organization, hifi4 related toolchain and so on. From this document, users can have an overall understanding of hifi4 related code. Currently, the hifi4 dsp is used to decode and encode audio streams in imx8qxp platform. It supports the following codecs. In addition, for current hifi4 framework and hifi4 driver, they can support up to 5 clients to run together.

Decoder:

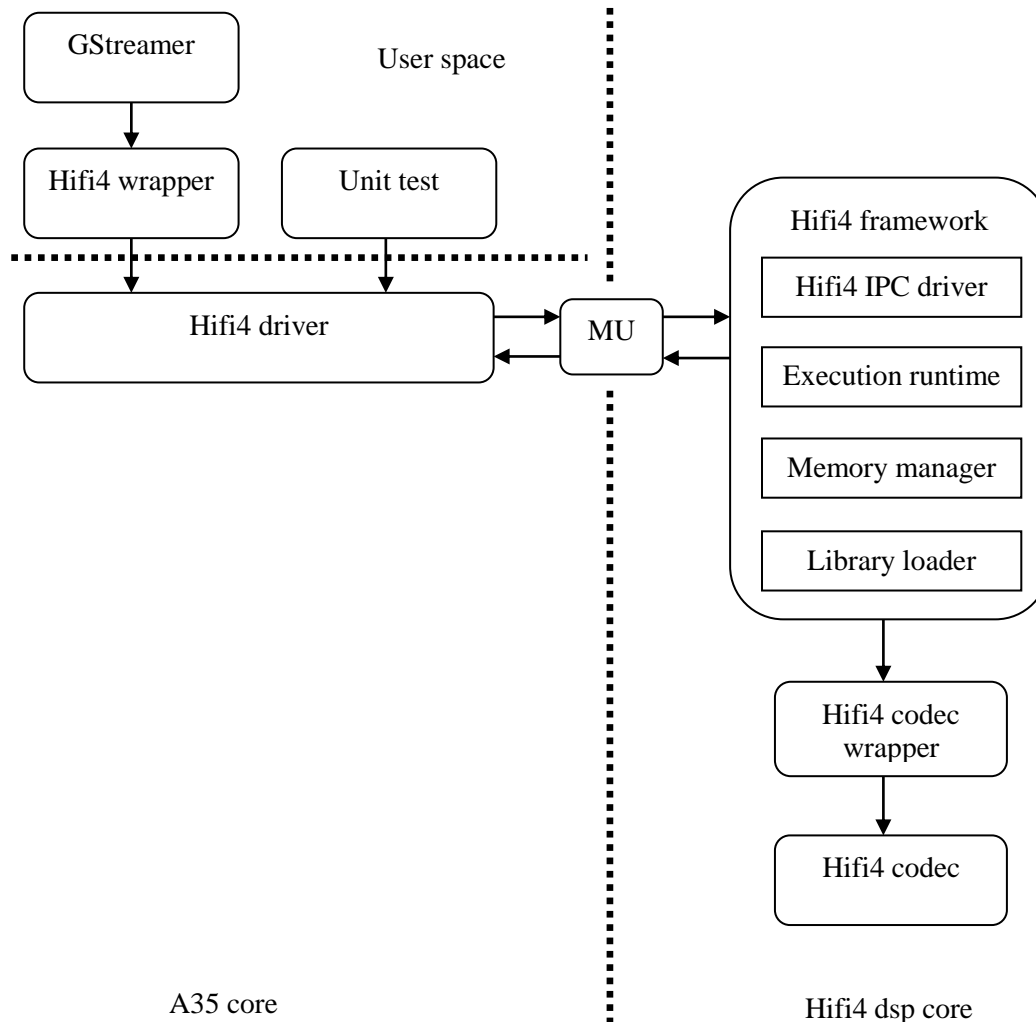
- AAC-LC
- AAC plus(HE-AAC/HE-AACv2)
- BSAC
- DAB+
- MP2
- MP3
- DRM
- SBC

Encoder:

- SBC

## 2 System Architecture

The following figure gives the overall system architecture of hifi4 related code.



The hifi4 related code mainly includes hifi4 framework, hifi4 driver, hifi4 wrapper, unit test, hifi4 codec wrapper and hifi4 codec. The hifi4 framework is the firmware code which is running on hifi4 dsp core. The hifi4 driver is used to load hifi4 firmware into memory and transfer messages between user space and hifi4 framework. The MU(message unit) is used to transfer messages between A35 and hifi4 dsp core. The hifi4 wrapper and unit test are application code in user space, which use ioctl() interface to transfer messages between hifi4 driver and user space. In addition, the hifi4 wrapper is used to provide unified interfaces for the GStreamer. The hifi4 codec provides actual decoding and encoding functions. The hifi4 codec wrapper is a wrapping code for the hifi4 codec and provides unified interfaces for the hifi4 framework.

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## 3 File Organization

The hifi4 framework, hifi4 wrapper and unit test's code are placed in imx-audio-framework package. The hifi4 driver's code belongs to linux kernel. The hifi4 codec wrapper and hifi4 codec are license restricted code, license authorization is required if you want to get them.

### 3.1 Hifi4 driver

The hifi4 driver's code can be found in linux kernel, it includes 3 files and the detailed information is as following.

- linux-kernel/sound/soc/fsl/fsl\_hifi4.c
- linux-kernel/sound/soc/fsl/fsl\_hifi4.h
- linux-kernel/include/uapi/linux/mxc\_hifi4.h

### 3.2 Hifi4 framework

The hifi4 framework's code is placed in the following path.

- imx-audio-framework/hifi4\_framework

### 3.3 Hifi4 wrapper and unit test

The hifi4 wrapper and unit test are placed in the following path.

- imx-audio-framework/hifi4\_wrapper
- imx-audio-framework/unit\_test

### 3.4 Interface header files

The hifi4 related code mainly include 4 interface header files.

- imx-audio-framework/include/mxc\_hifi4.h
- imx-audio-framework/include/hifi\_codec\_interface.h
- imx-audio-framework/hifi4\_wrapper/include/uni\_audio/fsl\_unia.h
- imx-audio-framework/hifi4\_wrapper/include/uni\_audio/fsl\_types.h

The mxc\_hifi4.h file is same as the header file in linux kernel, this file includes the interfaces and command definitions, which will be used by hifi4 wrapper and unit test. Similarly, the hifi\_codec\_interface.h file wraps the hifi4 codec's header files. It includes unified interfaces and command definitions, which can be used by hifi4 framework. The fsl\_unia.h and fsl\_types.h header files include interfaces and command definitions, which can be used by GStreamer.

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## 4 Hifi4 toolchain setup

Before you compile hifi4 related code, you should set up hifi4 related toolchains firstly. The hifi4 framework, hifi4 codec wrapper and hifi4 codec use Xtensa development toolchain. The hifi4 wrapper and unit test use the Linaro compiler toolchain for yocto platform.

### 4.1 Xtensa development toolchain

Xtensa development toolchain consist of two components that are installed separately on your linux system, including:

- Configuration-independent Xtensa Tool
- Configuration-specific core files and Xtensa Tool

For Configuration-independent Xtensa Tool, it is released by Cadence. For current code, the version of this tool is XtensaTools\_RF\_2016\_4\_linux.tgz. You can use two ways to get this package, one is downloading it from Xtensa Xplorer, the other is getting it from other people who have installed the Xtensa Xplorer.

For Configuration-specific core files and Xtensa Tool, it is released by NXP. For current code, the version of this tool is hifi4\_nxp\_v3\_3\_1\_2\_dev\_linux.tgz. In addition, you should also get the configurable memory map linker files from NXP, these files will be placed in memmap/mainlim folder.

Once you have gotten these two components, you can set up this toolchain as the following steps.

- Enter imx-audio-framework folder and execute the following command  
mkdir -p ./imx-audio-toolchain/Xtensa\_Tool/tools  
mkdir -p ./imx-audio-toolchain/Xtensa\_Tool/builds
- Set up Configuration-independent Xtensa Tool  
cd imx-audio-toolchain/Xtensa\_Tool  
tar zxvf XtensaTools\_RF\_2016\_4\_linux.tgz -C ./tools
- Set up Configuration-specific core files and Xtensa Tool  
cd imx-audio-toolchain/Xtensa\_Tool  
tar zxvf hifi4\_nxp\_v3\_3\_1\_2\_dev\_linux.tgz -C ./builds
- Copy configurable memory map files to the following path  
cd imx-audio-toolchain/Xtensa\_Tool  
cp -r memmap/mainlim ./builds/ RF-2016.4-linux/hifi4\_nxp\_v3\_3\_1\_2\_dev/xtensa-elf/lib
- Install Xtensa development toolchain  
cd imx-audio-toolchain/Xtensa\_Tool  
./ builds/RF-2016.4-linux/hifi4\_nxp\_v3\_3\_1\_2\_dev/install --xtensa-tools ./tools/RF-2016.4-linux/XtensaTools --registry ./tools/RF-2016.4-linux/XtensaTools/config
- Set the PATH environment variable  
export PATH= ./imx-audio-toolchain/Xtensa\_Tool/tools/RF-2016.4-linux/XtensaTools/bin:\$PATH
- Set the LM\_LICENSE\_FILE environment variable

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Xtensa development tools use FLEXlm for license management. FLEXlm licensing is required for tools such as the Xtensa Explorer, TIE Compiler, Xtensa C and C++ compiler. So if you plan to use a floating license, you need to install the FLEXlm license manager and set the LM\_LICENSE\_FILE environment variable. If any problem, you can find useful information from Cadence's document.

Xtensa® Development Tools Installation Guide User's Guide.doc

After the above steps, the Xtensa development toolchain is set up successfully.

## 4.2 Linaro compiler toolchain

Currently, gcc-linaro-4.9-2015.02-3-x86\_64\_aarch64-linux-gnu toolchain is used to compile the hifi4 wrapper and unit test's code for yocto platform. This toolchain should be placed in /usr folder of your linux server if you want to build code successfully, you can get more information from the Makefile file of hifi4 wrapper and unit test.

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## 5 Usage of Hifi4 binary files

### 5.1 Get Hifi4 binary files

You can get hifi4 binary files from NXP directly or compile the source code to produce them by yourself.

After hifi4 related toolchains have been installed on your server successfully, you can compile the hifi4 related code. You can just execute make command in imx-audio-framework folder to compile hifi4 framework, hifi4 wrapper and unit test. If you want to compile them separately, you can refer the REAME file in imx-audio-framework folder. After the compiling process, you can find the binary files in imx-audio-framework/release folder.

For hifi4 framework:

imx-audio-framework/release/hifi4.bin

For hifi4 wrapper:

imx-audio-framework/release/wrapper/lib\_dsp\_wrap\_arm\_elinux.so

For unit test:

imx-audio-framework/release/exe/dsp\_test

For hifi4 codec wrapper and hifi4 codec's binary files, you need to get the authorization.

### 5.2 Binary files in linux rootfs

If you want to use these binary files to run, you should place them into linux rootfs. The location of each binary is as following. For hifi4 framework, its location is determined by hifi4 driver, so you should keep it in the following place. For hifi4 wrapper, its location is determined by GStreamer, you should keep it in the following place. For unit test, you can change its location by yourself.

For hifi4 framework:

/lib/firmware/imx/hifi/hifi4.bin

For hifi4 wrapper:

/usr/lib/imx-mm/audio-codec/wrap/lib\_dsp\_wrap\_arm\_elinux.so

For hifi4 codec wrapper and hifi4 codec, you can keep them in the following place of linux rootfs.

/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_codec\_wrap.so  
/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_mp3\_dec.so  
/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_aac\_dec.so  
/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_bsac\_dec.so  
/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_dabplus\_dec.so  
/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_drm\_dec.so  
/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_mp2\_dec.so  
/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_sbc\_dec.so  
/usr/lib/imx-mm/audio-codec/hifi/lib\_dsp\_sbc\_enc.so



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## 5.3 Unit test and playing

After you have placed these binary files into correct location of rootfs. If you want to decode or encode audio streams directly, you can use the unit test binary file. For example, if you want to decode one .mp3 file, you can use the following command.

```
./dsp_test -f1 -d16 -itest.mp3 -otest.pcm
```

You can get more help information about dsp\_test by executing the following command.

```
./dsp_test
```

If you want to play one music by using GStreamer and hifi4 wrapper, you can use gplay and execute the following command.

```
gplay-1.0 test.mp3
```

## 6 Memory allocation for Hifi4

The hifi4 firmware is loaded into memory by hifi4 driver, the loading address is decided by memory map linker files of Xtensa development toolchain. You can change the loading address based on the following memory map list of imx8qxp.

Cortex-A35/Cortex-M4	Hifi4	Content
	0x80000000 ~ 0x806FFFFFFF	Reserved (Cannot be used)
0x59700000 ~ 0x5971FFFF	0x80700000 ~ 0x8071FFFF	Hifi4 OCRAM-System RAM
0x59720000 ~ 0x5973FFFF	0x80720000 ~ 0x8073FFFF	Hifi4 OCRAM-System ROM
	0x80740000 ~ 0x80FFFFFFF	Reserved (Cannot be used)
0x80700000 ~ 0x8073FFFF		Linux kernel (not visible from Hifi4)
0x81000000 ~ 0x9FFFFFFF	0x81000000 ~ 0x9FFFFFFF	SDRAM

Currently, linux kernel has reserved one memory for hifi4 dsp in SDRAM separately. The range of this reserved memory is 0x8e000000 ~ 0x8ffffff (32M bytes). You can set this reserved memory by changing the fsl-imx8qxp.dtsi file in linux-kernel/arch/arm64/boot/dts/freescale folder.

```
reserved-memory {
    .....

    hifi4_reserved: hifi4@0x8e000000 {
        no-map;
        reg = <0 0x8e000000 0 0x1ffffff>;
    };

    .....
}
```

For current reserved memory, hifi4 driver has split it into two parts. One part is used to keep the hifi4 firmware, the other part is considered as scratch memory for hifi4 framework. The detailed information about these two parts is as following.

0x8e000000 ~ 0x8eFFFFFFF	Hifi4 firmware(16M bytes)
0x8f000000 ~ 0x8FFFFFFF	Scratch memory(16M bytes)

Notice that if you make some changes for memory map linker files of Xtensa development toolchain, please do related changes for the hifi4 driver.