UG10156

Android User's Guide

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User guide

Document information

Information	Content
Keywords	Android, i.MX, android-17.0.0_1.0.0
Abstract	This document provides the technical information related to the i.MX 8 and i.MX 9 series devices.

1 Overview

This document provides the technical information related to the i.MX 8 and i.MX 9 series devices. It provides instructions for:

- Configuring a Linux OS build machine.
- Downloading, patching, and building the software components that create the Android system image.
- Building from sources and using pre-built images.
- Copying the images to boot media.
- Hardware and software configurations for programming the boot media and running the images.

For more information about building the Android platform, see source.android.com/docs/setup/build/building.

2 Preparation

2.1 Setting up your computer

To build the Android source files, use a computer running the Linux OS. The Ubuntu 22.04 64-bit version is the most tested environment for the Android 17 build.

To synchronize the code and build images of this release, the computer should at least have:

- 450 GB free disk space
- 64 GB RAM

Note:

*With a 64 GB RAM, if you run into segfaults or other errors related to memory when building the images, try reducing the `-j` value. In the demonstration commands in the following part of this document, the `-j` value is **4**.*

After installing the computer running Linux OS, check whether all the necessary packages are installed for an Android build. See the Android website https://source.android.com/docs/setup/start/requirements.

In addition to the packages requested on the Android website, the following packages are also needed:

```
sudo apt-get install uuid uuid-dev zlib1g-dev liblz-dev liblzo2-2 \
     liblzo2-dev lzop git curl u-boot-tools mtd-utils \
     android-sdk-libsparse-utils device-tree-compiler gdisk m4 bison \
     flex make libssl-dev gcc-multilib libgnutls28-dev \
     swig liblz4-tool libdw-dev dwarves bc cpio tar lz4 rsync \
     ninja-build clang libelf-dev build-essential libncurses5 \
     xxd unzip efitools
```

Note:

Configure Git before use. Set the name and email as follows:

- ```
  git config --global user.name "First Last"
  ```
- ```
  git config --global user.email "first.last@company.com"
  ```

To build Android in Docker container, skip this step of installing preceding packages and see Section 3.4 to build Docker image, which has full i.MX Android build environment.

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2.2 Unpacking the Android release package

After you set up a computer running Linux OS, unpack the Android release package by using the following command:

```
$ cd ~ (or any other directory you like)
$ tar xzvf imx-android-17.0.0_1.0.0.tar.gz
```

3 Building the Android platform for i.MX

3.1 Getting i.MX Android release source code

The i.MX Android release source code consists of three parts:

- NXP i.MX public source code, which is maintained in the GitHub repository.
- AOSP Android public source code, which is maintained in android.googlesource.com.
- NXP i.MX Android proprietary source code package, which is maintained in www.nxp.com.

Assume that you have the i.MX Android proprietary source code package `imx-android-17.0.0_1.0.0.tar.gz` under the `~/.` directory. To generate the i.MX Android release source code build environment, execute the following commands:

```
$ mkdir ~/bin
$ curl https://storage.googleapis.com/git-repo-downloads/repo > ~/bin/repo
$ chmod a+x ~/bin/repo
$ export PATH=${PATH}:~/bin
$ source ~/imx-android-17.0.0_1.0.0/imx_android_setup.sh
# By default, after preceding command finishes execution, current working
 directory changed to the i.MX Android source code root directory.
# ${MY_ANDROID} is referred as the i.MX Android source code root directory in
 all i.MX Android release documentation.
$ export MY_ANDROID=`pwd`
```

Note:

In the `imx_android_setup.sh` script, a `.xml` file that contains the code repository information is specified. To make the code be synchronized by this script the same as the release state, code repository revision is specified with the release tag in this file. The release tag is static and is not moved after the code is published, so no matter when `imx_android_setup.sh` is executed, the working area of the code repositories synchronized by this script are the same as the release state and images being built are the same as prebuilt images.

If a critical issue bugfix is published, another `.xml` file is published to reflect those changes on the source code. Then customers need to modify the `imx_android_setup.sh`. For this release, make the following changes in the script.

```
diff --git a/imx_android_setup.sh b/imx_android_setup.sh
index 324ec67..4618679 100644
--- a/imx_android_setup.sh
+++ b/imx_android_setup.sh
@@ -26,7 +26,7 @@ if [ ! -d "$android_builddir" ]; then
     # Create android build dir if it does not exist.
     mkdir "$android_builddir"
     cd "$android_builddir"
-    repo init -u https://github.com/nxp-imx/imx-manifest.git -b imx-android-17
 -m imx-android-17.0.0_1.0.0.xml
```


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```
+    repo init -u https://github.com/nxp-imx/imx-manifest.git -b imx-android-17
 -m rel_android-17.0.0_1.0.0.xml
       rc=$?
       if [ "$rc" != 0 ]; then
          echo "--------------------------------------------------"
```

The `wireless-regdb` repository may fail to be synchronized with the following log:

```
fatal: unable to access 'https://git.kernel.org/pub/scm/linux/kernel/git/
sforshee/wireless-regdb/': server certificate verification failed. CAfile: /etc/
ssl/certs/ca-certificates.crt CRLfile: none
```

If this issue occurs, execute the following command on the host to solve it:

```
$ git config --global http.sslVerify false
```

3.2 Building Android images

The Android image can be built after the source code has been downloaded (Section 3.1).

This section provides an overview of how to use the Android build system and what NXP did on it. Then it provides an example of how to build Android images for a specific board and preparation steps. Customers could follow these steps to do the preparation work and build the images.

First, the `source build/envsetup.sh` command is executed to import shell functions that are defined in `${MY_ANDROID}/build/envsetup.sh`.

Then, the `lunch <ProductName-nxp_stable-BuildMode>` command is executed to set up the build configuration.

The "Product Name" is the Android device name found in directory `${MY_ANDROID}/device/nxp/`. Search for the keyword `PRODUCT_NAME` under this directory for the product names. The following table lists the i.MX product names.

Table 1. i.MX product names

Product name	Description
`evk_8mm`	i.MX 8M Mini EVK Board
`evk_8mn`	i.MX 8M Nano EVK Board
`evk_8mp`	i.MX 8M Plus EVK Board
`evk_8mq`	i.MX 8M Quad EVK Board
`evk_8ulp`	i.MX 8ULP EVK Board
`mek_8q`	i.MX 8QuadMax/8QuadXPlus MEK Board
`evk_95`	i.MX 95 EVK Board
`evk_952`	i.MX 952 EVK Board

The "Build Mode" is used to specify what debug options are provided in the final image. The following table lists the build modes.

Table 2. Build mode

Build mode	Description
`user`	Production ready image, no debug

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Table 2. Build mode...*continued*

Build mode	Description
`userdebug`	Provides image with root access and debug, similar to `user`
`eng`	Development image with debug tools

This `lunch` command can be executed with an argument of `ProductName-nxp_stable-BuildMode`, such as lunch `evk_8mm-nxp_stable-userdebug`. It can also be issued without the argument and a menu presents for choosing a target.

After the two commands above are executed, the build process is not started yet. It is at a stage that the next command is necessary to be used to start the build process. The behavior of the i.MX Android build system used to be aligned with the original Android platform. The `make` command can start the build process and all images are built out. There are some differences. A shell script named `imx-make.sh` is provided and its symlink file can be found under `${MY_ANDROID}` directory, and `./imx-make.sh` should be executed first to start the build process.

The original purpose of this `imx-make.sh` is to build U-Boot/kernel before building Android images.

Google has started to put a limit on the host tools used when compiling Android code from Android 10.0. Some host tools necessary for building U-Boot/kernel now cannot be used in the Android build system, which is under the control of `soong_ui`, so U-Boot/kernel cannot be built together with Android images. Google also recommends using prebuilt binaries for U-Boot/kernel in the Android build system. It takes some steps to build U-Boot/kernel to binaries and put these binaries in proper directories, so some specific Android images depending on these binaries can be built without error. `imx-make.sh` is then added to do these steps to simplify the build work. After U-Boot/kernel is compiled, any build commands in standard Android can be used.

`imx-make.sh` can also start the `soong_ui` with the `make` function in `${MY_ANDROID}/build/envsetup.sh` to build the Android images after U-Boot/kernel is compiled, so customers can still build the i.MX Android images with only one command with this script.

i.MX Android platform needs some preparation for the first time when building the images. The image build steps are as follows:

1. Prepare the build environment for U-Boot and Linux kernel.
   This step is mandatory because there is no GCC cross-compile tool chain in the one in the AOSP codebase.
   An approach is provided to use the self-installed GCC cross-compile tool chain for both AArch32 and AArch64.
   a. Download the tool chain for the AArch32 and AArch64 on https://developer.arm.com/downloads/-/arm-gnu-toolchain-downloads page. It is recommended to use the 12.3.Rel1 version for this release. For AArch32 build, you can download the BareMetal target `arm-gnu-toolchain-12.3.rel1-x86_64-arm-none-eabi.tar.xz`. For AArch64 build, you can download the GNU/Linux target `arm-gnu-toolchain-12.3.rel1-x86_64-aarch64-none-linux-gnu.tar.xz`.
   b. Decompress the file into a path on the local disk, for example, to `/opt/`. Export variables named `AARCH32_GCC_CROSS_COMPILE` and `AARCH64_GCC_CROSS_COMPILE` to point to the tools as follows:

```
# For AArch32 toolchain
$ sudo tar -xvJf arm-gnu-toolchain-12.3.rel1-x86_64-arm-none-eabi.tar.xz -
C /opt
$ export AARCH32_GCC_CROSS_COMPILE=/opt/arm-gnu-toolchain-12.3.rel1-
x86_64-arm-none-eabi/bin/arm-none-eabi-
# For AArch64 toolchain
$ sudo tar -xvJf arm-gnu-toolchain-12.3.rel1-x86_64-aarch64-none-linux-
gnu.tar.xz -C /opt
$ export AARCH64_GCC_CROSS_COMPILE=/opt/arm-gnu-toolchain-12.3.rel1-
x86_64-aarch64-none-linux-gnu/bin/aarch64-none-linux-gnu-
```


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c. Set up the kernel build Bazel workspace. This script downloads the GKI kernel source through `repo sync` and creates symbolic links from the Bazel workspace to the Android source tree (`kernel_imx`, `nxp-mwifiex`, `verisilicon_sw_isp_vvcam`).

```
cd ${MY_ANDROID}
./setup_android_kernel_bazel.sh
```

After setup, `BAZEL_WORKSPACE_DIR` is automatically set in `~/.bashrc`. Add `AARCH32_GCC_CROSS_COMPILE` and `AARCH64_GCC_CROSS_COMPILE` exports to `~/.bashrc`, and then run `source ~/.bashrc` to apply all variables.
Note: *To build Android in a Docker container, skip this step of installing GCC cross-compile and Clang tools on the host. See Section 3.3 to build the Docker image, which has a full i.MX Android build environment.*

2. Change to the top-level build directory.

```
$ cd ${MY_ANDROID}
```

3. Set up the environment for building. This only configures the current terminal.

```
$ source build/envsetup.sh
```

4. Execute the Android `lunch` command. In this example, the setup is for the production image of i.MX 8M Mini EVK device with the `userdebug` type.

```
$ lunch evk_8mm-nxp_stable-userdebug
```

Note: *Execute the `lunch` command without any arguments to print the lunch menu. A warning occurs that the lunch menu cannot be displayed. Execute the following two commands, and then execute the `lunch` command to display the menu for selection.*

```
$ export TARGET_RELEASE=nxp_stable
$ build_build_var_cache
```

5. Execute the `imx-make.sh` script to generate the image.

```
$ ./imx-make.sh -j4 2>&1 | tee build-log.txt
```

The commands below can achieve the same result:

```
# firstly build bootloader and all kernel-related images with imx-make.sh
$ ./imx-make.sh bootloader bootimage vendorbootimage vendor_dlkmimage dtboimage
 system_dlkmimage -j4 2>&1 | tee build-log.txt
# build the Android images
$ make -j4 2>&1 | tee -a build-log.txt
```

The output of `make` command is written to standard output and `build-log.txt`. If there are any errors when building the image, error logs can be found in the `build-log.txt` file for checking.

To change `BUILD_ID` and `BUILD_NUMBER`, update `build_id.mk` in the `${MY_ANDROID}/device/nxp/` directory. For details, see the Android Frequently Asked Questions.

The following outputs are generated by default in `${MY_ANDROID}/out/target/product/evk_8mm`:

- `root/`: Root file system. It is used to generate `system.img` together with files in `system/`.
- `system/`: Android system binary/libraries. It is used to generate `system.img` together with files in `root/`.
- `recovery/`: Root file system, integrated into `vendor_boot.img` as a part of the RAMDisk and used by the Linux kernel when the system boots up.

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- `vendor_ramdisk/`: Integrated into `vendor_boot.img` as a part of the RAMDisk and used by the Linux kernel when the system boots up.
- `ramdisk/`: Integrated into the boot image as a part of the RAMDisk and used by the Linux kernel when the system boots up. Because GKI is enabled on i.MX 8M Mini EVK, this is integrated into `boot-imx.img`.
- `ramdisk.img`: Ramdisk image generated from `ramdisk/`. Not directly used.
- `dtbo-imx8mm.img`: Board's device tree binary. It is used to support MIPI-to-HDMI output on the i.MX 8M Mini EVK LPDDR4 board.
- `dtbo-imx8mm-m4.img`: Board's device tree binary. It is used to support MIPI-to-HDMI output and audio playback based on Cortex-M4 FreeRTOS on the i.MX 8M Mini EVK LPDDR4 board.
- `dtbo-imx8mm-mipi-panel.img`: Board's device tree binary. It is used to support RM67199 MIPI Panel output on the i.MX 8M Mini EVK LPDDR4 board.
- `dtbo-imx8mm-mipi-panel-rm67191.img`: Board's device tree binary. It is used to support RM67191 MIPI Panel output on the i.MX 8M Mini EVK LPDDR4 board.
- `dtbo-imx8mm-ddr4.img`: Board's device tree binary. It is used to support MIPI-to-HDMI output on the i.MX 8M Mini EVK DDR4 board.
- `vbmeta-imx8mm.img`: Android Verify boot metadata image for `dtbo-imx8mm.img`.
- `vbmeta-imx8mm-m4.img`: Android Verify boot metadata image for `dtbo-imx8mm-m4.img`.
- `vbmeta-imx8mm-mipi-panel.img`: Android Verify boot metadata image for `dtbo-imx8mm-mipi-panel.img`.
- `vbmeta-imx8mm-mipi-panel-rm67191.img`: Android Verify boot metadata image for `dtbo-imx8mm-mipi-panel-rm67191.img`.
- `vbmeta-imx8mm-ddr4.img`: Android Verify boot metadata image for `dtbo-imx8mm-ddr4.img`.
- `system.img`: System image generated from `system/` and `root/`.
- `system_dlkm.img`: System DLKM image generated from the prebuilt `system_dlkm.img`
- `system_dlkm-imx.img`: system dlkm image built from i.MX Kernel tree via Bazel/Kleaf.
- `system_ext.img`: System extension image generated from `system_ext/`.
- `product.img`: Product image generated from `product/`.
- `partition-table-13GB.img`: GPT partition table image for single-bootloader condition. Used for 16 GB SD card and eMMC.
- `partition-table-13GB-dual.img`: GPT partition table image for dual-bootloader condition. Used for 16 GB SD card and eMMC.
- `partition-table.img`: GPT partition table image for single-bootloader condition. Used for 32 GB SD card.
- `partition-table-dual.img`: GPT partition table image for dual-bootloader condition. Used for 32 GB SD card.
- `u-boot-imx8mm.imx`: U-Boot image without Trusty OS integrated for the i.MX 8M Mini EVK LPDDR4 board.
- `u-boot-imx8mm-trusty-secure-unlock.imx`: U-Boot image with Trusty OS integrated and demonstration secure unlock mechanism for i.MX 8M Mini EVK LPDDR4 board.
- `u-boot-imx8mm-evk-uuu.imx`: U-Boot image used by UUU for i.MX 8M Mini EVK LPDDR4 board. It is not flashed to MMC.
- `u-boot-imx8mm-ddr4.imx`: U-Boot image for i.MX 8M Mini EVK DDR4 board.
- `u-boot-imx8mm-ddr4-evk-uuu.imx`: U-Boot image used by UUU for i.MX 8M Mini EVK DDR4 board. It is not flashed to MMC.
- `spl-imx8mm-dual.bin`: SPL image without Trusty related configuration for i.MX 8M Mini EVK with LPDDR4 on board.
- `spl-imx8mm-trusty-dual.bin`: SPL image with Trusty related configuration for i.MX 8M Mini EVK with LPDDR4 on board.
- `spl-imx8mm-trusty-secure-unlock-dual.bin`: Secondary program loader image with Trusty and secure unlock related configurations for i.MX 8M Mini EVK LPDDR4 board.

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- `bootloader-imx8mm-dual.img`: Bootloader image without Trusty OS integrated for i.MX 8M Mini EVK with LPDDR4 on board.
- `bootloader-imx8mm-trusty-dual.img`: Bootloader image with Trusty OS integrated for i.MX 8M Mini EVK with LPDDR4 on board.
- `bootloader-imx8mm-trusty-secure-unlock-dual.img`: An image containing U-Boot proper, ATF, and Trusty OS. It is a demonstration of the secure unlock mechanism for i.MX 8M Mini EVK LPDDR4 board.
- `imx8mm_mcu_demo.img`: MCU FreeRTOS image to support audio playback on MCU side.
- `vendor.img`: Vendor image, which holds platform binaries. Mounted at `/vendor`.
- `vendor_dlkm.img`: Vendor DLKM image, which holds dynamically loadable kernel modules. Mounted at `/vendor_dlkm`.
- `super.img`: Super image, which is generated with `system.img`, `system_dlkm.img`, `system_ext.img`, `vendor.img`, `vendor_dlkm.img`, and `product.img`.
- `boot.img`: A composite image, which includes the AOSP generic kernel image and boot parameters.
- `boot-imx.img`: A composite image, which includes the kernel image built from i.MX kernel tree through Bazel/Kleaf and boot parameters.
- `init_boot.img`: Generic RAMDisk.
- `vendor_boot.img`: A composite image, which includes vendor RAMDisk and boot parameters.
- `rpmb_key_test.bin`: Prebuilt test RPMB key. Can be used to set the RPMB key as fixed 32 bytes 0x00.
- `testkey_public_rsa4096.bin`: Prebuilt AVB public key. It is extracted from the default AVB private key.

Note:

- *To build the U-Boot image separately, see Section 3.4.*
- *To build `boot.img`, see Section 3.5.*
- *To build `dtbo.img`, see Section 3.6.*

3.2.1 Configuration examples of building i.MX devices

The following table shows examples of using the `lunch` command to set up different i.MX devices with `userdebug` build mode. After the desired i.MX device is set up, the `imx-make.sh` script is used to start the build.

Table 3. i.MX device lunch examples

Board name	Lunch command
i.MX 8M Mini EVK board	`lunch evk_8mm-nxp_stable-userdebug`
i.MX 8M Nano EVK board	`lunch evk_8mn-nxp_stable-userdebug`
i.MX 8M Plus EVK board	`lunch evk_8mp-nxp_stable-userdebug`
i.MX 8M Quad WEVK/EVK board	`lunch evk_8mq-nxp_stable-userdebug`
i.MX 8ULP EVK board	`lunch evk_8ulp-nxp_stable-userdebug`
i.MX 8QuadMax/8QuadXPlus MEK board	`lunch mek_8q-nxp_stable-userdebug`
i.MX 95 EVK/FRDM-IMX95 board	`lunch evk_95-nxp_stable-userdebug`
i.MX 952 EVK/FRDM-IMX952 board	`lunch evk_952-nxp_stable-userdebug`
FRDM-IMX937 board	`lunch frdm_937-nxp_stable-userdebug`

3.2.2 Build mode selection

There are three types of build mode to select: `eng`, `user`, and `userdebug`.

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The userdebug build behaves the same as the user build, with the ability to enable additional debugging that normally violates the security model of the platform. This makes the userdebug build with greater diagnosis capabilities for user test.

The eng build prioritizes engineering productivity for engineers who work on the platform. The eng build turns off various optimizations used to provide a good user experience. Otherwise, the eng build behaves similar to the user and userdebug builds, so that device developers can see how the code behaves in those environments.

PRODUCT_PACKAGES_ENG, PRODUCT_PACKAGES_DEBUG and PRODUCT_PACKAGES can be used to specify the modules to be installed in the appropriate product makefiles.

The modules specified by PRODUCT_PACKAGES are always installed. For the effect of PRODUCT_PACKAGES_ENG and PRODUCT_PACKAGES_DEBUG, check the description below.

The main differences among the three modes are listed as follows:

- eng: development configuration with additional debugging tools
  - Installs modules specified by PRODUCT_PACKAGES_ENG and/or PRODUCT_PACKAGES_DEBUG.
  - Installs modules according to the product definition files.
  - ro.secure=0
  - ro.debuggable=1
  - ro.kernel.android.checkjni=1
  - adb is enabled by default.
- user: limited access; suited for production
  - Installs modules tagged with user.
  - Installs modules according to the product definition files.
  - ro.secure=1
  - ro.debuggable=0
  - adb is disabled by default.
- userdebug: like user but with root access and debuggability; preferred for debugging
  - Installs modules specified by PRODUCT_PACKAGES_DEBUG.
  - Installs modules according to the product definition files.
  - ro.debuggable=1
  - adb is enabled by default.

To build Android images, an example for the i.MX 8M Mini EVK LPDDR4 target is as follows:

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh   #set env
$ lunch evk_8mm-nxp_stable-userdebug
$ ./imx-make.sh -j4
```

The commands below can achieve the same result.

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch evk_8mm-nxp_stable-userdebug
$ ./imx-make.sh bootloader bootimage vendorbootimage vendor_dlkmimage dtboimage
 system_dlkmimage -j4
$ make -j4
```

For more Android platform building information, see https://source.android.com/docs/setup/build/building.

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3.2.3 Building with GMS package

Get the Google Mobile Services (GMS) package from Google. Put the GMS package into the `${MY_ANDROID}/vendor/partner_gms` folder. Make sure that the `product.mk` file has the following line:

```
$(call inherit-product-if-exists, vendor/partner_gms/products/gms.mk)
```

Then build the images. The GMS package is then installed into the target images.

Note:

`product.mk` means the build target make file. For example, for i.MX 8M Mini EVK Board, the `product.mk` is named `device/nxp/imx8m/evk_8mm/evk_8mm.mk`.

3.2.4 Building 32-bit and 64-bit images

The default is to build 64-bit-only images. To build 32-bit and 64-bit images, export the environment variables before building.

```
# build 32-bit and 64-bit images:
    $ export IMX_BUILD_32BIT_64BIT_ROOTFS=1
```

Then, see the build steps in Section 3.2 to build images.

3.3 Building an Android image With Docker

The Dockerfile can be found in the directory `${MY_ANDROID}/device/nxp/common/dockerbuild/`, which sets up a Ubuntu 20.04 image ready to build i.MX Android OS. You can use it to generate your own Docker image with full i.MX Android build environment. The process is as follows:

1. Build the Docker image:

```
$ cd ${Dockerfile_path}
# ${Dockerfile_path} can be ${MY_ANDROID}/device/nxp/common/dockerbuild/, or
 another path that you moved the Dockerfile to.
$ docker build --no-cache --build-arg userid=$(id -u) --build-arg groupid=
$(id -g) --build-arg username=$(id -un) -t <docker_image_name> .
# <docker_image_name> can be whatever you want, such as 'android-build'.
# '.' means using the current directory as the build context, it specifies
 where to find the files for the “context” of the build on the Docker daemon.
```

2. Start up a new container and mount your Android source codes to it with:

```
$ docker run --privileged -it -v ${MY_ANDROID}:/home/$(id -un)/android_src
 <docker_image_name>
> cd ~/android_src; source build/envsetup.sh
> lunch evk_8mm-nxp_stable-userdebug
> ./imx-make.sh -j4 2>&1 | tee build-log.txt
```

3. You can get the image what you want:

```
> exit
$ cd ${MY_ANDROID}/out/target/product/evk_8mm
```

Note:

- *If it fails to use the `apt` command to install packages in the process of Docker image build, configure the HTTP proxy. First, copy your host `apt.conf` with `cp /etc/apt/apt.conf ${Dockerfile_path}/`*

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`apt.conf`, or create a stripped down version. Then, remove the symbol "#" from the related content in Dockerfile.

- *If it fails to install clang tools in the process of Docker image build, remove the symbol "#" from the related content in Dockerfile, and try to build it again.*
- *If you manage Docker as a non-root user, preface the docker command with `sudo`, such as `sudo docker build ...` and `sudo docker run ...`.*
- *You can use the command `docker images` to see the existing Docker image and use `docker ps -a` to see the existing container. For other docker commands, see Docker Docs web.*
- *The Android build content above is taking the i.MX 8M Mini EVK board as an example. To build other board images or single image, refer to the other content of this section.*

3.4 Building U-Boot images

The U-Boot images can be generated separately. For example, you can generate a U-Boot image for i.MX 8M Mini EVK as follows:

```
# U-Boot image for i.MX 8M Mini EVK board
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch evk_8mm-nxp_stable-userdebug
$ ./imx-make.sh bootloader -j4
```

For other platforms, use **`lunch`** `<ProductName-nxp_stable-BuildMode>` to set up the build configuration. For detailed build configuration, see Section 3.2. Multiple U-Boot variants are generated for different purposes. For more details, check `{MY_Android}/device/nxp/{MY_PLATFORM}/{MY_PRODUCT}/UbootKernelBoardConfig.mk`.

To generate a U-Boot image with trusty, the size of bootloader image may be larger than the corresponding partition size, especially for the single bootloader configuration. You can build image with `USE_TEE_COMPRESS=true` to compress the TEE images. For example, execute the following command to compress the TEE image and generate a U-Boot image with a smaller size.

```
$ USE_TEE_COMPRESS=true ./imx-make.sh bootloader -j4
```

There is also an environment variable `BUILD_ENCRYPTED_BOOT` used to choose whether to insert a dummy dek_blob (`dek_blob_fit_dummy.bin`) to the compiled image, where the real dek_blob is inserted when encrypting the image. Execute the following command to generate a set of images with dummy dek_blob, but only the image with `trusty_secure_unlock_dual` supports encrypted boot.

```
$ BUILD_ENCRYPTED_BOOT=true ./imx-make.sh bootloader -j4
```

Note: *The command above only applies to i.MX 8M Plus, i.MX 8M Mini, i.MX 8M Nano, and i.MX 8M Quad. More details about encrypted boot, See Sections "Encrypted boot with AHAB" and "Encrypted boot with HABv4" in the i.MX Android Security User's Guide (UG10158).*

The following table lists the U-Boot configurations and images for i.MX 8M Mini EVK.

Table 4. U-Boot configurations and images for i.MX 8M Mini EVK

SoC	U-Boot configuration	Generated image	Description
i.MX 8M Mini	`imx8mm_evk_android_defconfig`	`u-boot-imx8mm.imx`	Default i.MX 8M Mini U-Boot image if trusty is not enabled.
i.MX 8M Mini	`imx8mm_evk_android_dual_defconfig`	`spl-imx8mm-dual.bin`, `bootloader-imx8mm-dual.img`	i.MX 8M Mini U-Boot image with dual-bootloader feature enabled.

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Table 4. U-Boot configurations and images for i.MX 8M Mini EVK*...continued*

SoC	U-Boot configuration	Generated image	Description
i.MX 8M Mini	`imx8mm_evk_android_trusty_dual_defconfig`	`spl-imx8mm-trusty-dual.bin`, `bootloader-imx8mm-trusty-dual.img`	i.MX 8M Mini U-Boot image with trusty and dual-bootloader feature enabled.
i.MX 8M Mini	`imx8mm_evk_android_trusty_rbidx_blob_dual_defconfig`	`spl-imx8mm-trusty-rbidx-blob-dual.bin`, `bootloader-imx8mm-trusty-rbidx-blob-dual.img`	i.MX 8M Mini U-Boot image with trusty, encrypted rollback index, and dual-bootloader feature enabled.
i.MX 8M Mini	`imx8mm_evk_android_trusty_secure_unlock_dual_defconfig`	`spl-imx8mm-trusty-secure-unlock-dual.bin`, `bootloader-imx8mm-trusty-secure-unlock-dual.img`	i.MX 8M Mini U-Boot with trusty, secure unlock, and dual-bootloader feature enabled.
i.MX 8M Mini	`imx8mm_ddr4_evk_android_defconfig`	`u-boot-imx8mm-ddr4.imx`	i.MX 8M Mini U-Boot image with DDR4 DRAM chip.
i.MX 8M Mini	`imx8mm_evk_android_uuu_defconfig`	`u-boot-imx8mm-evk-uuu.imx`	U-Boot image meant for flashing images for i.MX 8M Mini EVK. It should not be shipped to end users.
i.MX 8M Mini	`imx8mm_ddr4_evk_android_uuu_defconfig`	`u-boot-imx8mm-ddr4-evk-uuu.imx`	U-Boot image meant for flashing images for i.MX 8M Mini EVK with DDR4 DRAM chip. It should not be shipped to end users.

3.5 Building boot.img

The following commands are used to generate `boot.img` and `boot-imx.img` under Android environment:

```
# Boot image for i.MX 8M Mini EVK LPDDR4 board
$ source build/envsetup.sh
$ lunch evk_8mm-nxp_stable-userdebug
$ ./imx-make.sh bootimage -j4
```

For other platforms, use `lunch <ProductName-nxp_stable-buildMode>` to set up the build configuration. For detailed build configuration, see Section 3.2.

3.6 Building dtbo.img

DTBO image holds the device tree binary of the board.

The following commands are used to generate `dtbo.img` under the Android environment:

```
# dtbo image for i.MX 8M Mini EVK LPDDR4 board
$ source build/envsetup.sh
$ lunch evk_8mm-nxp_stable-userdebug
$ ./imx-make.sh dtboimage -j4
```

For other platforms, use `lunch <ProductName-nxp_stable-buildMode>` to set up the build configuration. For detailed build configuration, see Section 3.2.

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4 Running the Android platform with a prebuilt image

To test the Android platform before building any code, use the prebuilt images from the following packages and go to Section 5 and Section 6.

Table 5. Image packages

Image package	Description
`android-17.0.0_1.0.0_image_8mmevk.tar.gz`	Prebuilt-image for the i.MX 8M Mini EVK LPDDR4 board, which includes NXP extended features.
`android-17.0.0_1.0.0_image_8mnevk.tar.gz`	Prebuilt-image for the i.MX 8M Nano EVK board, which includes NXP extended features.
`android-17.0.0_1.0.0_image_8mpevk.tar.gz`	Prebuilt-image for the i.MX 8M Plus EVK board, which includes NXP extended features.
`android-17.0.0_1.0.0_image_8mqevk.tar.gz`	Prebuilt-image for the i.MX 8M Quad EVK board, which includes NXP extended features.
`android-17.0.0_1.0.0_image_8ulpevk.tar.gz`	Prebuilt-image for the i.MX 8ULP EVK board, which includes NXP extended features.
`android-17.0.0_1.0.0_image_95evk.tar.gz`	Prebuilt-image for the i.MX 95 EVK and FRDM-IMX95 boards, which includes NXP extended features.
`android-17.0.0_1.0.0_image_952evk.tar.gz`	Prebuilt-image for the i.MX 952 19x19 EVK and FRDM-IMX952 boards, which includes NXP extended features.
`android-17.0.0_1.0.0_image_937frdm.tar.gz`	Prebuilt-image for the FRDM-IMX937 board, which includes NXP extended features.

5 Programming images

The images from the prebuilt release package or created from source code contain the U-Boot bootloader, system image, GPT image, vendor image, and vbmeta image. At a minimum, the storage devices on the development system (MMC/SD or NAND) must be programmed with the U-Boot bootloader. The i.MX 8 and i.MX 9 series boot process determines what storage device to access based on the switch settings. When the bootloader is loaded and begins execution, the U-Boot environment space is then read to determine how to proceed with the boot process. For U-Boot environment settings, see Section 6.

The following download methods can be used to write the Android System Image:

- UUU to download all images to the eMMC or SD card.
- `imx-sdcard-partition.sh` to download all images to the SD card.
- `fastboot_imx_flashall` script to download all images to the eMMC or SD storage.

5.1 System on eMMC/SD

The images needed to create an Android system on eMMC/SD can either be obtained from the release package or be built from source.

The images needed to create an Android system on eMMC/SD are listed below. In some conditions, an MCU image is also needed, and it is not listed below.

- U-Boot image: `u-boot.imx` / `spl.bin`, `bootloader.img`
- GPT table image: `partition-table.img`
- Android dtbo image: `dtbo.img`
- Android boot image: `boot.img`

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- Android initialization boot image: `init_boot.img`
- Android vendor boot image: `vendor_boot.img`
- Android super image: `super.img`
- Android verify boot metadata image: `vbmeta.img`

5.1.1 Storage partitions

The layout of the eMMC card for Android system is shown below:

- [Partition type/index] which is defined in the GPT.
- [Start Offset] shows where partition is started, unit in MB.

The userdata partition is used to put the unpacked codes/data of the applications, system configuration database, and so on. In normal boot mode, the root file system is first mounted with RAMDisk from boot partition, and then the logical system partition is mounted and switched as root. In recovery mode, the root file system is mounted with RAMDisk from the boot partition.

Table 6. Storage partitions

Partition type/index	Name	Start offset	Size	File system	Content
N/A	`bootloader0`	Listed in the following table	4 MB	N/A	`spl.imx/u-boot.imx`
(1)	`bootloader_a`	8 MB	16 MB	N/A	`bootloader.img`
(2)	`bootloader_b`	Following `bootloader_a`	16 MB	N/A	`bootloader.img`
1/(3)	`dtbo_a`	8 MB (following `bootloader_b`)	4 MB	N/A	`dtbo.img`
2/(4)	`dtbo_b`	`Follow dtbo_a`	4 MB	N/A	`dtbo.img`
3 (5)	`boot_a`	`Follow dtbo_b`	64 MB	`boot.img` format, a kernel + part of RAMDisk	`boot.img`
4 (6)	`boot_b`	`Follow boot_a`	64 MB	`boot.img` format, a kernel + part of RAMDisk	`boot.img`
5 (7)	`init_boot_a`	`Follow boot_b`	8 MB	part of RAMdisk	`init_boot.img`
6 (8)	`init_boot_b`	`Follow init_boot_a`	8 MB	part of RAMdisk	`init_boot.img`
7 (9)	`vendor_boot_a`	`Follow init_boot_b`	64 MB	Part of RAMDisk	`vendor_boot.img`
8 (10)	`vendor_boot_a`	`Follow boot_b`	64 MB	Part of RAMDisk	`vendor_boot.img`
9 (11)	`misc`	`Follow vendor_boot_b`	4 MB	N/A	For recovery storage bootloader message, reserve.
10 (12)	`metadata`	`Follow misc`	64 MB	f2fs	Metadata of OTA update, remount, and so on.
11 (13)	`presistdata`	`Follow metadata`	1 MB	N/A	the option to operate unlock \unlock
12 (14)	`super`	`Follow presistdata`	4096 MB	N/A	`system.img`, `system_dlkm.img`, `system_ext.img`,

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Table 6. Storage partitions*...continued*

Partition type/index	Name	Start offset	Size	File system	Content
					`vendor.img`, `vendor_dlkm.img`, and `product.img`
13 (15)	`userdata`	`Follow super`	Remained space	f2fs	Application data storage for system application. And for emulated storage, in `/data/media/<user_id>` dir.
14 (6)	`fbmisc`	`Follow userdata`	1 MB	N/A	To store the state of lock/unlock.
15 (17)	`vbmeta_b`	`Follow fbmisc`	1 MB	N/A	To store the verify boot's metadata.
16 (18)	`vbmeta_b`	`Follow vbmeta_a`	1 MB	N/A	To store the verify boot's metadata.

Table 7. bootloader0 offset

SoC	bootloader0 offset in eMMC boot0 partition	bootloader0 offset in SD card
i.MX 8M Mini	33 KB	33 KB
i.MX 8M Nano	0	32 KB
i.MX 8M Plus	0	32 KB
i.MX 8M Quad	33 KB	33 KB
i.MX 8ULP	0	32 KB
i.MX 8Quad Max Rev.B	0	32 KB
i.MX 8QuadXPlus Rev.B	32 KB	32 KB
i.MX 8QuadXPlus Rev.C	0	32 KB
i.MX 95	0	32 KB
i.MX 952	0	32 KB
i.MX 937	0	32 KB

Note:

For the preceding table, in the "Partition Type/Index" column and "Start offset" column, the contents in brackets is specific for dual-bootloader condition.

To create these partitions, use UUU described in the *Android Quick Start Guide* (UG10157), or use format tools in the prebuilt directory.

The script below can be used to partition an SD card and download images to them as shown in the partition table above:

```
$ sudo ./imx-sdcard-partition.sh -f <soc_name> -D
 <directory_containing_the_images> /dev/sdX
# <soc_name> can be as imx8mm, imx8mn, imx8mp, imx8mq, imx8qm, imx8qxp, imx95,
 imx952, imx937.
```

Note:

- *The SD card should be connected to the host via a USB adapter.*

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- *The minimum size of SD card is 16 GB.*
- *The `-c` option with an argument can be used to select a proper partition table image based on the SD card volume size. If it is not used, the default `partition-table.img` or `partition-table-dual.img` is used. Check the Android Quick Start Guide (UG10157) for the target SD card volume size of the partition table images.*
- *In `/dev/sdX`, the `X` is the disk index from 'a' to 'z', which varies on each Linux PC.*
- *Unmount all the SD card partitions before running the script.*
- *If the images to be flashed are in the same directory as `imx-sdcard-partition.sh`, there is no need to use `-D <directory_containing_the_images>`.*
- *This script requires the `simg2img` tool to be installed on your PC. The `simg2img` is a tool, which converts Android sparse images to raw images on the Linux host PC. The `android-tools-fsutils` package includes the `simg2img` command for Ubuntu Linux.*

5.1.2 Downloading images with UUU

UUU can be used to download all images into a target device. It is a quick and easy tool for downloading images. See the *Android Quick Start Guide* (UG10157) for detailed description of UUU.

5.1.3 Downloading images with fastboot_imx_flashall script

UUU can be used to flash the Android system image into the board, but it needs to make the board enter serial download mode first, and make the board enter boot mode once flashing is finished.

A new `fastboot_imx_flashall` script is supported to use fastboot to flash the Android system image into the board. It is more flexible. To use the new script, the board must be able to enter fastboot mode and the device must be unlocked. The table below lists the `fastboot_imx_flashall` scripts.

Table 8. fastboot_imx_flashall script

Name	Host system to execute the script
`fastboot_imx_flashall.sh`	Linux OS
`fastboot_imx_flashall.bat`	Windows OS

With the help of `fastboot_imx_flashall` scripts, you do not need to use fastboot to flash Android images one-by-one manually. These scripts automatically flash all images with only one command.

With virtual A/B feature enabled, your host fastboot tool version should be equal to or later than 30.0.4. You can download the host fastboot tool from the Android website or build it with the Android project. Based on Section 3.2, follow the steps below to build fastboot:

```
$ cd ${MY_ANDROID}
$ make -j4 fastboot
```

After the build process finishes building fastboot, the directory to find the fastboot is as follows:

- Linux version binary file: `${MY_ANDROID}/out/host/linux-x86/bin`
- Windows version binary file: `${MY_ANDROID}/out/host/windows-x86/bin`

The way to use these scripts is as follows:

- Linux shell script usage: `sudo fastboot_imx_flashall.sh <option>`
- Windows batch script usage: `fastboot_imx_flashall.bat <option>`

```
Options:
      -h                Displays this help message
      -f soc_name       Flashes the Android image file with soc_name
```


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```
      -a                Only flashes the image to slot_a
      -b                Only flashes the image to slot_b
      -c card_size      If this option is not used, partition-table.img or
 partition-table-dual.img is flashed
                        If this option is used, partition-table-
<card_size>GB.img or partition-table-<card_size>GB-dual.img is flashed
                        Make sure the corresponding partition table image file
 exists.
      -m                Flashes the MCU image.
      -u uboot_feature  Flashes U-Boot or spl&bootloader images with
 "uboot_feature" in their names
                            For Standard Android:
                                If the parameter after "-u" option contains the
 string of "dual", the spl&bootloader image is flashed;
                                Otherwise U-Boot image is flashed.
                            For Android Automotive:
                                Only dual-bootloader feature is supported. By
 default, spl&bootloader image is flashed.
      -d dtb_feature    Flashes dtbo, vbmeta and recovery image file with
 "dtb_feature" in their names
                            If not set, use default dtbo, vbmeta and recovery
 image
      -e               Erases user data after all image files are flashed.
      -l               Locks the device after all image files are flashed.
      -D directory     Directory of images.
                       If this script is executed in the directory of the
 images, it does not need to use this option.
      -s ser_num       Serial number of the board.
                       If only one board connected to computer, it does not need
 to use this option
```

Note:

- *The `-f` option is mandatory. The SoC name can be `imx8mm`, `imx8mn`, `imx8mp`, `imx8mq`, `imx8qm`, `imx8qxp`, `imx95`, `imx952`, and `imx937`.*
- *i.MX 8ULP EVK does not support the `-m` option in this script. To flash the MCU image for i.MX 8ULP EVK, use the `uuu_imx_android_flash` scripts.*
- *The `-c` option chooses the partition table image. For the suitable storage size of a partition table image, see the Android Quick Start Guide (UG10157).*
- *Boot the device to U-Boot fastboot mode, and then execute these scripts. The device should be unlocked first.*

Example:

```
sudo ./fastboot_imx_flashall.sh -f imx8mm -a -e -u trusty-dual -D /imx_android/
evk_8mm/
```

Options explanation:

- `-f imx8mm`: Flashes images for the i.MX 8M Mini EVK board.
- `-a`: Only flashes slot a.
- `-e`: Erases user data after all image files are flashed.
- `-D /imx_android/evk_8mm/`: Images to be flashed are in the directory of `/imx_android/evk_8mm/`.
- `-u trusty-dual`: Flashes `spl-imx8mm-trusty-dual.bin` and `bootloader-imx8mm-trusty-dual.img`.

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5.1.4 Downloading a single image with fastboot

Sometimes only a single image needs to be flashed again with fastboot for debug purpose.

With dynamic partition feature enabled, fastboot is also implemented in userspace (recovery) in addition to the implementation in U-Boot. The partitions are categorized into three. Fastboot implemented in U-Boot and userspace can individually recognize part of the partitions. The relationship between them are listed in the following table.

Table 9. Relationship between partitions

Partition category	Partition	Can be recognized by
U-Boot hard-coded partition	`bootloader0`, `gpt`, `mcu_os`	U-Boot fastboot
EFI partition	`boot_a`, `boot_b`, `vendor_boot_a`, `vendor_boot_b`, `dtbo_a`, `dtbo_b`, `vbmeta_a`, `vbmeta_b`, `misc`, `metadata`, `presistdata`, `super`, `userdata`, `fbmisc`	U-Boot fastboot, userspace fastboot
Logical partition	`system_a`, `system_b`, `system_ext_a`, `system_dlkm_a`, `system_dlkm_b`, `system_ext_b`, `vendor_a`, `vendor_b`, `vendor_dlkm_a`, `vendor_dlkm_b`, `product_a`, `product_b`	Userspace fastboot

To enter U-Boot fastboot mode, for example, make the board enter U-Boot command mode, and execute the following command on the console:

```
> fastboot 0
```

To enter userspace fastboot mode, two commands are provided as follows for different conditions. You may need root permission on Linux OS:

```
# board in U-Boot fastboot mode, execute the following command on the host
$ fastboot reboot fastboot
# board boot up to the Android system, execute the following command on the host
$ adb reboot fastboot
```

To use fastboot tool on the host to operate on a specific partition, choose the proper fastboot implemented on the device, which can recognize the partition to be operated on. For example, to flash the system.img to the partition of `system_a`, make the board enter userspace fastboot mode, and execute the following command on the host:

```
$ fastboot flash system_a system.img
```

6 Booting

This chapter describes booting from eMMC/SD.

6.1 Booting from SD/eMMC

6.1.1 Booting from SD/eMMC on the i.MX 8M Mini EVK board

The following tables list the boot switch settings to control the boot storage for Rev. C boards with LPDDR4.

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Table 10. Boot device switch settings

Boot device switch	SW1101 (1-10 bit)	SW1102 (1-10 bit)
SD boot	0110110010	0001101000
Download mode	1010xxxxxx	xxxxxxxxxx
eMMC boot	0110110001	0001010100

To test booting from SD, change the board Boot_Mode switch to SW1101 0110110010 (1-10 bit) and SW1102 0001101000 (1-10 bit).

To test booting from eMMC, change the board Boot_Mode switch to SW1101 0110110010 (1-10 bit) and SW1102 0001010100 (1-10 bit).

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set `bootargs` environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        #Save the environments
```

Note:

`bootargs` environment is an optional setting for `boota`. The `boot.img` includes a default `bootargs`, which is used if there is no `bootargs` defined in U-Boot.

6.1.2 Booting from SD/eMMC on the i.MX 8M Nano board

The following tables list the boot switch settings to control the boot storage.

Table 11. Boot device switch settings

Boot mode switch	SW1101 (from 1-4 bit)
SD boot	1100
eMMC boot	0100
Download mode	1000

- To boot from SD, change the board Boot_Mode switch to SW1101 1100 (from 1-4 bit).
- To boot from eMMC, change the board Boot_Mode switch to SW1101 0100 (from 1-4 bit).

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set `bootargs` environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        #Save the environments
```

Note:

`bootargs` environment is an optional setting for boota. The `boot.img` includes a default `bootargs`, which is used if there is no `bootargs` defined in U-Boot.

6.1.3 Booting from SD/eMMC on the i.MX 8M Plus EVK board

The following tables list the boot switch settings to control the boot storage.

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Table 12. Boot device switch settings

Boot mode switch	SW4
SD boot	0011
eMMC boot	0010
Download mode	0001

- To boot from SD, change the board Boot_Mode switch SW4 to 0011 (from 1-4 bit).
- To boot from eMMC, change the board Boot_Mode switch SW4 to 0010 (from 1-4 bit).

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set bootargs environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        #Save the environments
```

Note:

`bootargs` environment is an optional setting for `boota`. The `boot.img` includes a default `bootargs`, which is used if if there is no `bootargs` defined in U-Boot.

6.1.4 Booting from SD/eMMC on the i.MX 8M Quad WEVK/EVK board

The following tables list the boot switch settings to control the boot storage.

Table 13. Boot device switch settings

Boot device switch	External SD card	eMMC
SW01 (1-2 bit)	1100	0010

Table 14. Boot mode switch settings

Boot mode switch	Download Mode (MfgTool mode)	Boot mode
SW02 (1-2 bit)	01	10

To test booting from SD, change the board Boot_Mode switch to 10 (1-2 bit) and SW801 1100 (1-4 bit).

To test booting from eMMC, change the board Boot_Mode switch to 10 (1-2 bit) and SW801 0010 (1-4 bit).

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set bootargs environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        # Save the environments
```

Note:

`bootargs` environment is an optional setting for `boota`. The `boot.img` includes a default `bootargs`, which is used if if there is no `bootargs` defined in U-Boot.

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6.1.5 Booting from eMMC on the i.MX 8ULP EVK board

The following tables list the boot switch settings to control the boot storage.

Table 15. Boot device switch settings

Boot mode switch	SW5 (from 1-8 bit)
eMMC boot	00000001
Download mode	00000010

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set `bootargs` environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        # Save the environments
```

6.1.6 Booting from SD/eMMC on the i.MX 8QuadMax MEK board

The following tables list the boot switch settings to control the boot storage.

Table 16. Boot device switch settings

Boot mode switch	SW2 (from 1-6 bit)
SD boot	001100
eMMC boot	000100
Download mode	001000

To test booting from SD, change the board Boot_Mode switch to 001100 (1-6 bit).

To test booting from eMMC, change the board Boot_Mode switch to 000100 (1-6 bit).

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set bootargs environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        # Save the environments
```

Note:

`bootargs` environment is an optional setting for `boota`. The `boot.img` includes a default `bootargs`, which is used if if there is no `bootargs` defined in U-Boot.

6.1.7 Booting from SD/eMMC on the i.MX 8QuadXPlus MEK board

The following tables list the boot switch settings to control the boot storage.

Table 17. Boot device switch settings

Boot mode switch	SW2 (from 1-4 bit)
SD boot	1100
eMMC boot	0100

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Table 17. Boot device switch settings*...continued*

Boot mode switch	SW2 (from 1-4 bit)
Download mode	1000

To test booting from SD, change the board Boot_Mode switch to 1100 (1-4 bit).

To test booting from eMMC, change the board Boot_Mode switch to 0100 (1-4 bit).

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set `bootargs` environment in U-Boot.

To clear the bootargs environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        # Save the environments
```

Note:

`bootargs` environment is an optional setting for `boota`. The `boot.img` includes a default `bootargs`, which is used if if there is no `bootargs` defined in U-Boot.

6.1.8 Booting from SD/eMMC on the i.MX 95 EVK and FRDM-IMX95 boards

The following tables list the boot switch settings to control the boot storage of i.MX 95 EVK.

Table 18. Boot device switch settings

Boot mode switch	SW7 (from 1-4 bit)
SD boot	1011
eMMC boot	1010
Download mode	1001

To test booting from SD, change the board Boot_Mode switch to SW7 1011 (from 1-4 bit) on i.MX 95 EVK.

To test booting from eMMC, change the board Boot_Mode switch to SW7 1010 (from 1-4 bit) on i.MX 95 EVK.

The following tables list the boot switch settings to control the boot storage of FRDM-IMX95.

Table 19. Boot device switch settings

Boot mode switch	SW1 (from 1-2 bit)
SD boot	11
eMMC boot	10
Download mode	01

To test booting from SD, change the board Boot_Mode switch to SW1 11 (from 1-2 bit).

To test booting from eMMC, change the board Boot_Mode switch to SW1 10 (from 1-2 bit).

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set the `bootargs` environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        #Save the environments
```


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Note:

`bootargs` environment is an optional setting for `boota`. The `boot.img` includes a default `bootargs`, which is used if there is no `bootargs` defined in U-Boot.

6.1.9 Booting from SD/eMMC on the i.MX 952 EVK and FRDM-IMX952 boards

The following table lists the boot switch settings to control the boot storage for i.MX 952 EVK.

Table 20. Boot device switch settings for i.MX 952 EVK

Boot mode switch	SW7 (from 1-4 bit)
SD boot	x011
eMMC boot	x010
Download mode	x001

To test booting from SD, change the board Boot_Mode switch to SW7 x011 (from 1-4 bit).

To test booting from eMMC, change the board Boot_Mode switch to SW7 x010 (from 1-4 bit).

The following table lists the boot switch settings to control the boot storage for FRDM-IMX952.

Table 21. Boot device switch settings for FRDM-IMX952

Boot mode switch	SW7 (from 1-4 bit)
SD boot	11
eMMC boot	10
Download mode	01

To test booting from SD, change the board Boot_Mode switch to SW1 11 (from 1-2 bit).

To test booting from eMMC, change the board Boot_Mode switch to SW1 10 (from 1-2 bit).

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set the `bootargs` environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        #Save the environments
```

Note:

`bootargs` environment is an optional setting for `boota`. The `boot.img` includes a default `bootargs`, which is used if there is no `bootargs` defined in U-Boot.

6.1.10 Booting from SD/eMMC on the FRDM-IMX95 and FRDM-IMX937 boards

The following tables list the boot switch settings to control the boot storage of FRDM-IMX937.

Table 22. Boot device switch settings

Boot mode switch	SW1 (from 1-2 bit)
SD boot	11
eMMC boot	10
Download mode	01

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To test booting from SD, change the board Boot_Mode switch to SW1 11 (from 1-2 bit) on FRDM-IMX95 and FRDM-IMX937.

To test booting from eMMC, change the board Boot_Mode switch to SW1 10 (from 1-2 bit) on FRDM-IMX95 and FRDM-IMX937.

The default environment is in `boot.img`. To use the default environment in `boot.img`, do not set the `bootargs` environment in U-Boot.

To clear the `bootargs` environment being set and saved before, use the following command:

```
U-Boot > setenv bootargs
U-Boot > saveenv        #Save the environments
```

Note:

`bootargs` environment is an optional setting for `boota`. The `boot.img` includes a default `bootargs`, which is used if there is no `bootargs` defined in U-Boot.

6.2 Boot-up configurations

This section explains some common boot-up configurations such as U-Boot environments, kernel command line, and DM-verity configurations.

6.2.1 U-Boot environment

- `bootcmd`: the first command to run after U-Boot boot.
- `bootargs`: the kernel command line, which the bootloader passes to the kernel, `bootargs` environment is optional for `boota`. There is a default `bootargs` stored in `boot.img`. If you do not define the `bootargs` environment, it uses the default `bootargs` inside the image.
  To use the default environment in `boot.img`, use the following command to clear the `bootargs` environment.

  ```
  > setenv bootargs
  ```

  The default `bootargs` can be set by `BOARD_KERNEL_CMDLINE` in `BoardConfig.mk` under `${MY_ANDROID}/device/nxp`. If the environment variable `append_bootargs` is set, the value of `append_bootargs` is appended to the end of the default `bootargs` automatically.
  After enabling the boot header v4, `bootconfig` is supported to separate the configuration parameters for Android user space from those for the kernel. Parameters starting with `androidboot.*` should be set in `bootconfig` instead of `bootargs`. The default `bootconfig` should be set by `BOARD_BOOTCONFIG` in `BoardConfig.mk` under `${MY_ANDROID}/device/nxp`.
  If the environment variable `append_bootconfig` is set, the value of `append_bootconfig` is appended to the end of the default `bootconfig` automatically. `bootconfig` does not accept redefined parameters. Therefore, if a variable has been defined in `BOARD_BOOTCONFIG` at build time, use the `:=` operator to explicitly override the previous value. For example:

  ```
  U-Boot=> setenv append_bootconfig androidboot.wificountrycode:=US
  ```

  Note: *`append_bootargs` and `append_bootconfig` are only tools to facilitate the feature enable/disable during development. All `bootargs` and `bootconfig` should be set by `BOARD_KERNEL_CMDLINE` and `BOARD_BOOTCONFIG` in formal releases. See Section "Disabling development options in U-Boot" in the i.MX Android Security User's Guide (UG10158).*

- `boota`:

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The `boota` command parses the `boot.img` header to get the Image and ramdisk. It also passes the `bootargs` as needed (it only passes `bootargs` in `boot.img` when it cannot find `bootargs` variable in your U-Boot environment). To boot up the Android system, execute the following command:

```
> boota
```

To boot into recovery mode, execute the following command:

```
> boota recovery
```

6.2.2 Kernel command line (bootargs) and bootconfig

Depending on the different booting/usage scenarios, you may need different boot parameters set for `bootargs` (`/proc/cmdline`) and `bootconfig` (`/proc/bootconfig`).

Table 23. Kernel boot parameters

Kernel parameter	Description	Typical value	Used when
`console`	Where to output kernel log by `printk`.	`console=ttymxc0`	i.MX 8M Mini uses `console=ttymxc1`.
`init`	Tells kernel where the init file is located.	`init=/init`	All use cases. `init` in the Android platform is located in "/" instead of in "/sbin".
`cma`	CMA memory size for GPU/VPU physical memory allocation.	`cma=800M or cma=1280M` or `cma=800M@0x960M-0xe00M` • For i.MX 8M Mini and i.MX 8QuadMax, it is 800 MB by default. • For i.MX 8M Quad WEVK/EVK, it is 1280 MB by default. • For i.MX 8QuadXPlus and 8QuadMax, it is 800 MB by default. • For i.MX 95 EVK, it is 1024M@0xBF0M-0xFF0M by default.	The start address is 0x9600 0000 and the end address is 0xDFFFFFFFF. The CMA size can be configured to other value, but cannot exceed 1184 MB, because the Cortex-M4 core also allocates memory from CMA and Cortex-M4 cannot use the memory larger than 0xDF FFFFFFF.
`moal.mod_para`	It is used to set driver load arguments for NXP mxmdriver Wi-Fi driver.	• `moal.mod_para=wifi_mod_para_sd8987.conf` • `moal.mod_para=wifi_mod_para_powersave.conf`	-
`transparent_hugepage`	It is used to change the sysfs boot time defaults of Transparent Hugepage support.	`transparent_hugepage=never/always/madvise`	-
`loop.max_part`	Defines how many partitions to be able to manage per loop device.	`loop.max_part=7`	-
`swiotlb`	It is used to configure the SWIOTLB size. The kernel default value is 64 MB.	`swiotlb=65536`	i.MX 8M Plus EVK is configured to `128 MB (swiotlb=65536)` to fix SWIOTLB overflow issue of the Wi-Fi driver.
`snd_pcm.max_alloc_per_card`	It is used to set the maximum total allocation bytes per card, required by LPA case. For details, see Section 8.2.1.	`snd_pcm.max_alloc_per_card=134217728`	-
`firmware_class.path`	It is used to set the Wi-Fi firmware path.	`firmware_class.path=/vendor/firmware`	-

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Table 23. Kernel boot parameters*...continued*

Kernel parameter	Description	Typical value	Used when
`androidboot.console`	The Android shell console. It should be the same as `console=`.	`androidboot.console=ttymxc0`	To use the default shell job control, such as Ctrl+C to terminate a running process, set this for the kernel.
`androidboot.selinux`	Argument to disable selinux check when userdebug/eng build images are used. For details about selinux, see Security-Enhanced Linux in Android.	`androidboot.selinux=permissive`	Setting this argument also bypasses all the selinux rules defined in Android system. It is recommended to set this argument for internal developer.
`androidboot.lcd_density`	It is used to set the display density and over write `ro.sf.lcd_density` in `init.rc` for MIPI-DSI-to-HDMI display.	`androidboot.lcd_density=160`	-
`androidboot.displaymode`	It is used to configure the kernel/driver work mode/fps.	• 4K display should be configured as: `androidboot.displaymode=4k`. The default fps is 60 fps. To configure fps, change this value to 4kp60/4kp50/4kp30. • 1080p display should be configured as: `androidboot.displaymode=1080p`. The default fps is 60fps. To configure fps, change this value to 1080p60/1080p50/1080p30. • 720p display should be configured as: `androidboot.displaymode=720p`. The default fps is 60fps. To configure fps, change this value to 720p60/720p50/720p30. • 480p display should be configured as: `androidboot.displaymode=480p`. The default FPS is 60fps. To configure fps, change this value to 480p60/480p50/480p30. • For other displaymode which is not 4k/1080p/720p/480p or fps is not 60/50/30, for example: 1024x768p24 display should be configured as: `androidboot.displaymode=1024x768p24`. • 1080p60 display can be configured as: `androidboot.displaymode=1920x1080p60` or `androidboot.displaymode=1080p`.	The system will find out and work at the best display mode, and display mode can be changed through this `bootargs`.
`androidboot.fbTileSupport`	It is used to enable framebuffer super tile output.	`androidboot.fbTileSupport=enable`	It should not be set when connecting the MIPI-DSI-to-HDMI display or MIPI panel display.
`androidboot.dpu_composition`	It is used to determine if DPU composition can be enabled	Default Vaule: `androidboot.dpu_composition=0`, which means to use GPU to do composition by default.	Setting it to **1** means gralloc allocate layer buffer without tiled format and 2d (DPU) compostion is used. In this case, `setprop vendor.hwc.prefer.2d-composition 0` and restarting the hardware composer service can switch to use the GPU to do composition.

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Table 23. Kernel boot parameters*...continued*

Kernel parameter	Description	Typical value	Used when
`androidboot.wificountrycode=CN`	It is used to set Wi-Fi country code. Different countries use different Wi-Fi channels. For details, see the i.MX Android Frequently Asked Questions.	`androidboot.wificountrycode=CN`	-
`androidboot.vendor.sysrq`	It is used to enable `sysrq`.	`androidboot.vendor.sysrq=1`	-
`androidboot.powersave.usb`	It is used to enable USB `runtime_pm` (auto).	`androidboot.powersave.usb=true`	-
`androidboot.secureime`	It is used to enable NXP SecureIME. It is only available on i.MX 8ULP with MIPI panel as display.	`androidboot.secureime=enabled`	-
`androidboot.lpa.enable`	It is used to enable Low Power Audio (LPA), only available on i.MX 95 EVK, i.MX 952 EVK, i.MX 8M Plus EVK, i.MX 8M Mini EVK, and i.MX 8ULP EVK.	`androidboot.lpa.enable=1`	-

6.2.3 DM-verity configuration

DM-verity (device-mapper-verity) provides transparent integrity checking of block devices. It can prevent device from running unauthorized images. This feature is enabled by default. Replacing one or more partitions (`boot`, `vendor`, `system`, `vbmeta`) will make the board unbootable. Disabling DM-verity provides convenience for developers, but the device is unprotected.

To disable DM-verity, perform the following steps:

1. Unlock the device.
   a. Boot up the device.
   b. Choose **Settings** -> **Developer Options** -> **OEM Unlocking** to enable OEM unlocking.
   c. Execute the following command on the target side to make the board enter fastboot mode:

```
reboot bootloader
```

   d. Unlock the device. Execute the following command on the host side:

```
fastboot oem unlock
```

   e. Wait until the unlock process is complete.
2. Disable DM-verity.
   a. Boot up the device.
   b. Disable the DM-verity feature. Execute the following command on the host side:

```
adb root
adb disable-verity
adb reboot
```


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6.2.4 Full reset for i.MX 8QuadMAX/8QuadXPlus, i.MX 95, and i.MX 952

For i.MX 8QuadMAX/8QuadXPlus, i.MX 95, and i.MX 952, a normal reboot command does not trigger a full board reset because of the existence of the system manager or system control unit on the device. Instead, to trigger a full board reset, run the following command on the U-Boot command line interface:

```
U-Boot=> reboot
```

Also, you can use the following command on the device console on boot-up:

```
reboot board_reset
```

To trigger a full board reset at the Android application layer, call the reboot method provided by the PowerManager. The following is an example:

```
PowerManager pm = (PowerManager) getSystemService(Context.POWER_SERVICE);
pm.reboot("board_reset");
```

7 Over-The-Air (OTA) update

7.1 Building OTA update packages

7.1.1 Building target files

You can use the following commands to generate target files under the Android environment:

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch evk_8mm-nxp_stable-userdebug
$ ./imx-make.sh bootloader -j4
$ make target-files-package -j4
```

After building is complete, you can find the target files in the following path:

```
${MY_ANDROID}/out/target/product/evk_8mm/obj/PACKAGING/
target_files_intermediates/evk_8mm-ota-**.zip
```

7.1.2 Building a full update package

A full update package contains the entire final state of the device (system, boot, product, and vendor partitions).

You can use the following commands to build a full update package under the Android environment:

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch evk_8mm-nxp_stable-userdebug
$ ./imx-make.sh bootloader bootimage vendorbootimage vendor_dlkmimage dtboimage
 system_dlkmimage -j4
$ make otapackage -j4
```

After building is complete, the OTA packages are displayed in the following path:

```
${MY_ANDROID}/out/target/product/evk_8mm/evk_8mm-ota-**.zip
```


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The target `otapackage` depends on a target file package. When the `otapackage` is made, the executed commands include one like below:

```
out/host/linux-x86/bin/ota_from_target_files evk_8mm-target_files-**.zip
 evk_8mm-ota-**.zip
```

`evk_8mm-ota-**.zip` contains `payload.bin` and `payload_properties.txt`. These two files are used for full update, which is called `full-ota.zip` for convenience.

7.1.3 Building an incremental update package

An incremental update contains a set of binary patches to be applied to the data that is already on the device. This can result in considerably smaller update packages:

- Files that have not changed do not need to be included.
- Files that have changed are often very similar to their previous versions, so the package only needs to contain encoding of the differences between the two files.

Before building an incremental update package, see Section 7.1.1 to build two target files:

- `PREVIOUS-target_files.zip`: one old package that has already been applied on the device.
- `NEW-target_files.zip`: the latest package that is waiting to be applied on the device.

Then use the following commands to generate the incremental update package under the Android environment:

```
$ cd ${MY_ANDROID}
$ out/host/linux-x86/bin/ota_from_target_files -i PREVIOUS-target_files.zip NEW-
target_files.zip incremental-ota.zip
```

`${MY_ANDROID}/incremental-ota.zip` contains `payload.bin` and `payload_properties.txt`. The two files are used for incremental update.

Note:

To apply the incremental update package on a device successfully, the images running on the device should be the same as the images in `PREVIOUS-target_files.zip`. This can be achieved in either of the following ways. The second one is recommended.

- *Flash the images in `PREVIOUS-target_files.zip` instead of the images generated under the `$OUT` directory when building the target file package.*
- *Apply a full update package, which is generated from `PREVIOUS-target_files.zip`. An example command to generate a full update package from a target file package is provided in Section 7.1.2.*

For more information about incremental updates, see https://source.android.com/docs/core/ota/tools#incremental-updates.

7.1.4 Building an OTA package for single-bootloader image

The dual-bootloader feature divides the default `u-boot.imx` into two parts: `spl.bin` and `bootloader.img`. `spl.bin` leads to the bootloader0 partition, which is managed by U-Boot itself, while `bootloader.img` leads to the bootloader_a/bootloader_b partitions, which are managed by GPT. Taking i.MX 8M Mini as an example, the layout of the dual-bootloader images is as follows.

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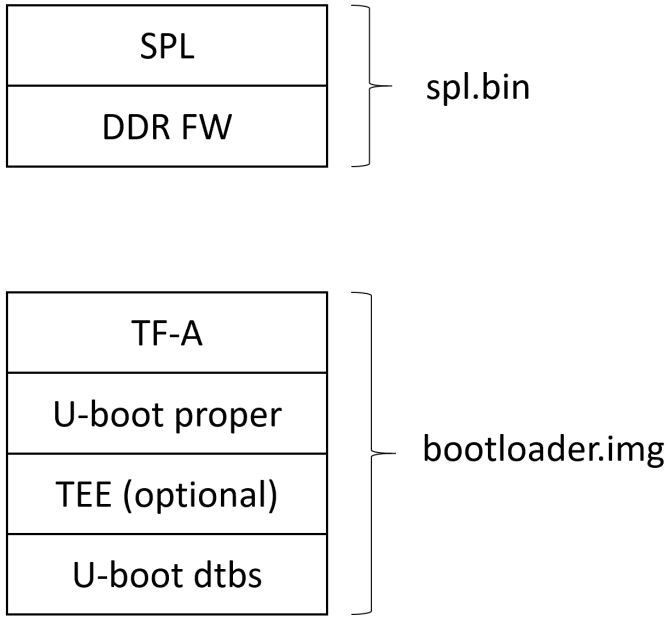


Figure 1. Dual-bootloader image layout

The dual-bootloader feature is the default configuration and it's useful as it can provide a secure way to update the bootloader image. But if the single-bootloader image is used, to build the OTA package, some configurations need to be made. Taking i.MX 8M Mini as an example, add the following changes to `${MY_ANDROID}/device/nxp`:

```
diff --git a/imx8m/evk_8mm/AndroidBoard.mk b/imx8m/evk_8mm/AndroidBoard.mk
index 3305270b4..c402abc05 100644
--- a/imx8m/evk_8mm/AndroidBoard.mk
+++ b/imx8m/evk_8mm/AndroidBoard.mk
@@ -7,5 +7,3 @@ include $(FSL_PROPRIETARY_PATH)/fsl-proprietary/media-profile/
media-profile.mk
 include $(FSL_PROPRIETARY_PATH)/fsl-proprietary/sensor/fsl-sensor.mk
 -include $(IMX_MEDIA_CODEC_XML_PATH)/mediacodec-profile/mediacodec-profile.mk

-BOARD_PACK_RADIOIMAGES += bootloader.img
-INSTALLED_RADIOIMAGE_TARGET  += $(PRODUCT_OUT)/bootloader.img
diff --git a/imx8m/evk_8mm/BoardConfig.mk b/imx8m/evk_8mm/BoardConfig.mk
index c6f94c82f..66414a65d 100644
--- a/imx8m/evk_8mm/BoardConfig.mk
+++ b/imx8m/evk_8mm/BoardConfig.mk
@@ -67,7 +67,6 @@ BOARD_PREBUILT_DTBOIMAGE := $(OUT_DIR)/target/product/
$(PRODUCT_DEVICE)/dtbo-imx
 BOARD_USES_METADATA_PARTITION := true
 BOARD_ROOT_EXTRA_FOLDERS += metadata

-AB_OTA_PARTITIONS += bootloader

 # -------@block_security-------
 ENABLE_CFI=false
```

Note that Trusty is not integrated in the single-bootloader image.

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7.1.5 Building an OTA package with the postinstall command

Postinstall is a mechanism to execute a specified command in the updated partition during the OTA process. To enable this mechanism, add some build configurations.

This release provides a demonstration for enabling the vendor partition postinstall command. You can find the following code in the repository under the `${MY_ANDROID}/device/nxp` directory:

```
AB_OTA_POSTINSTALL_CONFIG += \
RUN_POSTINSTALL_vendor=true \
POSTINSTALL_PATH_vendor=bin/imx_ota_postinstall \
FILESYSTEM_TYPE_vendor=erofs \
POSTINSTALL_OPTIONAL_vendor=false
```

The preceding configurations are as follows:

- The vendor partition postinstall command is enabled.
- After the vendor partition is updated, the vendor partition with updated image is mounted on the `/postinstall` directory, and the `/postinstall/bin/imx_ota_postinstall` command is executed.
- The updated vendor partition is of the `erofs` type.
- The vendor partition postinstall command is not optional. If the command fails, the whole OTA process will not be marked as a success.

As you can find in the source code, the preceding configurations do not take effect by default unless a variable named `IMX_OTA_POSTINSTALL` is assigned with an appropriate value. For example, assign a value when executing the command to build an OTA package as follows:

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch evk_8mm-nxp_stable-userdebug
$ ./imx-make.sh bootloader -j4
$ make otapackage -j4 IMX_OTA_POSTINSTALL=1
```

This postinstall mechanism is not mutually exclusive with a full update package or incremental update package. It can be used with both of them.

In the demonstration, `imx_ota_postinstall` corresponds to a shell script, and the source code is under the `${MY_ANDROID}/vendor/nxp-opensource/imx/ota_postinstall/` directory. It is used to update the `bootloader0` partition, which does not have a/b slot.

Note: *Be aware of the risk that the update of the `bootloader0` partition may fail and there is no way to roll back.*

During the execution of this command, it invokes the `dd` command to write the file `/postinstall/etc/bootloader0.img` to the appropriate offset of the boot device. You can modify the configuration source code to decide which file is copied to the vendor partition and named as `bootloader0.img`. Taking i.MX 8M Mini EVK as an example, the following code lines in the release code can copy the U-Boot image with Trusty OS to vendor partition and name it as `bootloader0.img`. If the dual-bootloader feature is enabled, the SPL image should be copied. If the board is closed, the image should be signed first.

```
PRODUCT_COPY_FILES += \
  $(OUT_DIR)/target/product/$(firstword $(PRODUCT_DEVICE))/obj/UBOOT_COLLECTION/
u-boot-imx8mm-trusty.imx:$(TARGET_COPY_OUT_VENDOR)/etc/bootloader0.img
```

See the *i.MX Android Security User's Guide* (UG10158) about how to sign the `bootloader0` image with CST. In the default configuration, an SPL image is copied to be `bootloader0.img` because dual-bootloader is recommended.

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Implement your own postinstall command and perform the operations as needed during the OTA process.

7.1.6 Building an OTA package with encrypted boot enabled

A full upgrade image is needed during OTA when Encrypted Boot is enabled. Currently, only dual-bootloader enabled images support encrypted boot OTA. The following table lists the target SPL and bootloader images, which are supported by encrypted boot OTA.

Table 24. Target SPL and bootloader images

Board	Target SPL image	Target bootloader image
i.MX 8M Mini EVK Board	`spl-imx8mm-trusty-dual.bin`	`bootloader-imx8mm-trusty-dual.img`
i.MX 8M Nano EVK Board	`spl-imx8mn-trusty-dual.bin`	`bootloader-imx8mn-trusty-dual.img`
i.MX 8M Plus EVK Board	`spl-imx8mp-trusty-dual.bin`	`bootloader-imx8mp-trusty-dual.img`
i.MX 8M Quad EVK Board	`spl-imx8mq-trusty-wevk-dual.bin`	`bootloader-imx8mq-trusty-wevk-dual.img`
i.MX 8ULP 9x9 EVK Board	`spl-imx8ulp-trusty-9x9-dual.bin`	`bootloader-imx8ulp-trusty-9x9-dual.img`
i.MX 8QuadMax MEK Board	`spl-imx8qm-trusty-dual.bin`	`bootloader-imx8qm-trusty-dual.img`
i.MX 8QuadXPlus MEK Board	`spl-imx8qxp-trusty-dual.bin`	`bootloader-imx8qxp-trusty-dual.img`
i.MX 8QuadXPlus C0 MEK Board	`spl-imx8qxp-trusty-c0-dual.bin`	`bootloader-imx8qxp-trusty-c0-dual.img`

7.1.6.1 Building SPL and bootloader images with encrypted boot enabled

Before compilation begins, see Section "Building Android images to construct the containers" and Section "Enabling the encrypted boot support in U-Boot" in the *i.MX Android Security User's Guide* (UG10158) to enable the encrypted boot function by modifying the target defconfig files.

Images including the encrypted boot enabled SPL and bootloader can be generated with the following commands:

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch evk_8mm-nxp_stable-userdebug
$ BUILD_ENCRYPTED_BOOT=true ./imx-make.sh bootloader -j4
```

7.1.6.2 Encrypting SPL and bootloader images

To encrypt SPL and bootloader images, see Section "Encrypted boot with AHAB" and Section "Encrypted boot with HABv4" in the *i.MX Android Security User's Guide* (UG10158). But there are two differences:

- Do not insert the Encryption Key (DEK) Blob to final images. Save these DEK Blob files such as `dek_blob_spl.bin` and `dek_blob_bl.bin`, which are necessary for encrypted boot OTA.
- To facilitate remote upgrades, all the CST commands that encrypt images should be appended with the `-d` parameter. This parameter requires CST to reuse DEK Blob files that already exist in the current directory.

7.1.6.3 Building an OTA package with encrypted boot

Move the encrypted target SPL and bootloader images to the directory of `${MY_ANDROID}/out/tagret/product/${TARGET_PRODUCT}/obj/UBOOT_COLLECTION/`. Override the original target files.

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Execute the following command to generate an OTA package, which includes the encrypted SPL and bootloader images.

```
$ make otapackage -j24 IMX_OTA_POSTINSTALL=1
```

Then the OTA package includes the encrypted SPL and bootloader images. Besides the OTA package, DEK Blobs of SPL and bootloader images need to be provisioned into the device before applying the OTA package. For how to provision DEK Blobs into devices and enable the encrypted boot OTA, see Section "Setting up encrypted boot OTA" in the *i.MX Android Security User's Guide* (UG10158).

7.2 Implementing OTA update

7.2.1 Using update_engine_client to update the Android platform

`update_engine_client` is a pre-built tool to support A/B (seamless) system updates. It supports updating system from a remote server or board's storage.

To update the system from a remote server, perform the following steps:

1. Copy `full-ota.zip` or `incremental-ota.zip` (generated in Section 7.1.2 and Section 7.1.3) to the HTTP server (for example, `192.168.1.1:/var/www/`).
2. Unzip the packages to get `payload.bin` and `payload_properties.txt`.
3. Push `payload_properties.txt` to the board's storage:

```
adb push payload_properties.txt /data/ota_package
```

4. Input the following command on the board's console to update:

```
su
update_engine_client --payload=http://192.168.1.1:10888/payload.bin --update
 --headers="$(cat /data/ota_package/payload_properties.txt)"
```

5. The system will update in the background. After it finishes, it shows "Update successfully applied, waiting to reboot" in the logcat.

To update the system from board's storage, perform the following steps:

1. Unzip `full-ota.zip` or `incremental-ota.zip` (Generated in Section 7.1.2 and Section 7.1.3) to get `payload.bin` and `payload_properties.txt`.
2. Push `payload.bin` and `payload_properties.txt` to the board's storage:

```
adb push payload.bin payload_properties.txt /data/ota_package
```

3. Input the following command on the board's console to update:

```
su
update_engine_client --payload=file:///data/ota_package/payload.bin --update
 --headers="$(cat /data/ota_package/payload_properties.txt)"
```

4. The system will update in the background. After it finishes, it displays "Update successfully applied, waiting to reboot" in the logcat.

Note:

Make sure that the -- header equals to the exact content of `payload_properties.txt` without the "space" or "return" character.

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7.2.2 Using a customized application to update the Android platform

Google has provided a reference OTA application (named as SystemUpdaterSample) under `${MY_ANDROID}/bootable/recovery/updater_sample`, which can do the OTA operations. Perform the following steps to use this application:

1. Generate a JSON configuration file from the OTA package.

```
out/host/linux-x86/bin/gen_update_config \
--ab_install_type=STREAMING \
--ab_force_switch_slot \
full-ota.zip \
full-ota.json \
http://192.168.1.1:10888/full-ota.zip
```

   And you can use the following command to generate incremental OTA JSON file:

```
out/host/linux-x86/bin/gen_update_config \
--ab_install_type=STREAMING \
--ab_force_switch_slot \
incremental-ota.zip \
incremental-ota.json \
http://192.168.1.1:10888/incremental-ota.zip
```

   Note:
   http://192.168.1.1:10888/full-ota.zip is a remote server address, which can hold the OTA package.

2. Set up the HTTP server (for example, Lighttpd, Apache).
   You need one HTTP server to hold the OTA packages.

```
scp full-ota.zip ${server_ota_folder}
scp incremental-ota.zip ${server_ota_folder}
```

   Note:
   - *`server_ota_folder` is one folder on your remote server to hold OTA packages.*
   - *`full-ota.zip` and `incremental-ota.zip` are built from Section 7.1.2 and Section 7.1.3.*

3. Push JSON files to the board.
   a. Use the following command to push JSON files to the board:

```
adb push full-ota.json /data/local/tmp
adb push incremental-ota.json /data/local/tmp
```

   b. Use the following command to move JSON files to the private folder of the SystemUpdaterSample application:

```
su
mkdir -m 777 -p /data/user/0/com.example.android.systemupdatersample/files
mkdir -m 777 -p /data/user/0/com.example.android.systemupdatersample/
files/configs
cp /data/local/tmp/*.json /data/user/0/
com.example.android.systemupdatersample/files/configs
chmod 777 /data/user/0/com.example.android.systemupdatersample/files/
configs/*.json
```

   Note:
   If you use the Android Automotive system, move JSON files to the `user/10` folder as follows:

```
su
```


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```
mkdir -m 777 -p /data/user/10/com.example.android.systemupdatersample/files
mkdir -m 777 -p /data/user/10/com.example.android.systemupdatersample/files/
configs
cp /data/local/tmp/*.json /data/user/10/
com.example.android.systemupdatersample/files/configs
chmod 777 /data/user/10/com.example.android.systemupdatersample/files/
configs/*.json
```

4. Open the SystemUpdaterSample OTA application.
   There are many buttons on the UI. The following are their brief descriptions:

```
Reload - reloads update configs from device storage.
View config - shows selected update config.
Apply - applies selected update config.
Stop - cancel running update, calls UpdateEngine#cancel.
Reset - reset update, calls UpdateEngine#resetStatus, can be called only when
 update is not running.
Suspend - suspend running update, uses UpdateEngine#cancel.
Resume - resumes suspended update, uses UpdateEngine#applyPayload.
Switch Slot - if ab_config.force_switch_slot config set true, this button
 will be enabled after payload is applied, to switch A/B slot on next reboot.
```

   First, choose the desired JSON configuration file. Then, click the **APPLY** button to do the update. After the update is complete, you can see "SUCCESS" in the **Engine error** text field, and "REBOOT_REQUIRED" in the **Updater state** text field. Finally, reboot the board to finish the whole OTA update.

Note:

The OTA package includes the DTBO image, which stores the board's DTB. There may be many DTS for one board. For example, in `${MY_ANDROID}/device/nxp/imx8m/evk_8mm/BoardConfig.mk`:

```
TARGET_BOARD_DTS_CONFIG ?= imx8mm-ddr4:imx8mm-ddr4-evk.dtb
TARGET_BOARD_DTS_CONFIG += imx8mm:imx8mm-evk-usd-wifi.dtb
TARGET_BOARD_DTS_CONFIG += imx8mm-mipi-panel:imx8mm-evk-rm67199.dtb
TARGET_BOARD_DTS_CONFIG += imx8mm-mipi-panel-rm67191:imx8mm-evk-rm67191.dtb
TARGET_BOARD_DTS_CONFIG += imx8mm-m4:imx8mm-evk-rpmsg.dtb
```

There is one variable to specify which DTBO image is stored in the OTA package:

```
BOARD_PREBUILT_DTBOIMAGE := out/target/product/evk_8mm/dtbo-imx8mm.img
```

Therefore, the default OTA package can only be applied for `evk_8mm` with single MIPI-DSI-to-HDMI display. To generate an OTA package for `evk_8mm` with an RM67199 MIPI panel display, modify this `BOARD_PREBUILT_DTBOIMAGE` as follows:

```
BOARD_PREBUILT_DTBOIMAGE := out/target/product/evk_8mm/dtbo-imx8mm-mipi-
panel.img
```

To generate an OTA package for `evk_8mm` with an RM67191 MIPI panel display, modify this `BOARD_PREBUILT_DTBOIMAGE` as follows:

```
BOARD_PREBUILT_DTBOIMAGE := out/target/product/evk_8mm/dtbo-imx8mm-mipi-panel-
rm67191.img
```

For detailed information about A/B OTA updates, see https://source.android.com/devices/tech/ota/ab/.

For detailed information about the SystemUpdaterSample application, see https://android.googlesource.com/platform/bootable/recovery/+/refs/heads/master/updater_sample/.

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8 Customized configuration

8.1 Camera configuration

Camera HAL on running reads the information in `/vendor/etc/configs/camera_config_${ro.boot.soc_type}.json` to configure the camera. `${ro.boot.soc_type}` is the value of property `ro.boot.soc_type`. The source of this json file is in the repository under `${MY_ANDROID}/device/nxp/`. To configure the camera, make modifications on this source file.

Some parameters have default values in the camera HAL. It is not necessary to set these parameters in the JSON file if the default values can have cameras work normally.

8.1.1 Configuring the rear and front cameras

`camera_type` and `camera_name` can be used together in the camera configuration JSON file to specify the camera used as the front or rear camera.

The value of `camera_type` can be "front" and "back". "front" represents the front camera, and "back" represents the rear camera.

The value of "camera_name" represents the camera. It should be either `v4l2_dbg_chip_ident.match.name` returned from `v4l2's VIDIOC_DBG_G_CHIP_IDENT ioctl` or `v4l2_capability.driver` returned from `v4l2's VIDIOC_QUERYCAP ioctl`. `v4l2_dbg_chip_ident` and `v4l2_capability` are structure types defined in camera HAL. Camera HAL goes through all the V4L2 devices present in the system to find the corresponding camera and output the information to logcat.

`OmitFrame` is used to skip the first several frames. `cam_blit_csc` is used to specify the hardware used to do csc in camera HAL. `cam_blit_copy` is used to specify the hardware used to do memory copy in camera HAL.

`media_profiles_V1_0.xml` in `/vendor/etc` is used to configure the parameters used in the recording video. NXP provides several media profile examples that help customers align the parameters with their camera module capability and device definition.

Table 25. Media profile parameters

Profile file name	Rear camera	Front camera
`media_profiles_1080p.xml`	Maximum to 1080P, 30 fps, and 8 Mbps for recording video	Maximum to 720P, 30 fps, and 3 Mbps for recording video
`media_profiles_720p.xml`	Maximum to 720P, 30 fps, and 3 Mbps for recording video	Maximum to 720P, 30 fps, and 3 Mbps for recording video
`media_profiles_480p.xml`	Maximum to 480P, 30 fps, and 2 Mbps for recording video	Maximum to 480P, 30 fps, and 2 Mbps for recording video
`media_profiles_qvga.xml`	Maximum to QVGA, 15 fps, and 128 Kbps for recording video	Maximum to QVGA, 15 fps, and 128 Kbps for recording video
`media_profiles_95-dual-os08a20.xml`	Maximum to 1080P, 60 fps, and 16 Mbps for recording video	Maximum to 1080P, 60 fps, and 16 Mbps for recording video

Note:

Because not all UVC cameras can have 1080P, 30 fps resolution setting, it is recommended to use `media_profiles_480p.xml` for any board's configuration, which defines the UVC as the rear camera or front camera.

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8.1.2 Configuring camera sensor parameters

Camera sensor parameters are used to calculate view angle when doing panorama. The focal length and sensitive element size should be customized based on the camera sensor being used.

The following table lists the parameters for camera sensor. These parameters can be configured in the camera configuration JSON file.

Table 26. Camera sensor parameters

Parameter	Description
`ActiveArrayWidth`	Maximum active pixel width for camera sensor.
`ActiveArrayHeight`	Maximum active pixel height for camera sensor.
`PixelArrayWidth`	Maximum pixel width for camera sensor.
`PixelArrayHeight`	Maximum pixel height for camera sensor.
`orientation`	If (`PixelArrayWidth` > `PixelArrayHeight`), and the screen is portrait (w < h), set it to **90**. If (`PixelArrayWidth` < `PixelArrayHeight`), and the screen is landscape (w > h), set it to **90**. Otherwise, set it to **0**.
`FocalLength`	Focal length.
`MinFrameDuration`	Minimum FPS.
`MaxFrameDuration`	Maximum FPS.
`MaxJpegSize`	Maximum JPEG size.
`PhysicalWidth`	`PixelArrayWidth * siz_of_one_pixel` (For OV5640, it is 1.4 um; For MAX9286, it is 4.2 um. For AP1302, it is 3.0 um.)
`PhysicalHeight`	`PixelArrayHeight * siz_of_one_pixel` (For OV5640, it is 1.4 um; For MAX9286, it is 4.2 um. For AP1302, it is 3.0 um.)

8.1.3 Making cameras work on i.MX 8M Plus EVK with non-default images

The default image for i.MX 8M Plus EVK supports OS08A20 + OS08A20 and the cameras can work after the image is flashed and boot up. To make cameras work with non-default images, execute the following additional commands:

- Basler (CSI1) + OV5640 (CSI2) or only Basler (CSI1) on the host

```
# flash the image
sudo ./fastboot_imx_flashall.sh -f imx8mp -a -e -d basler-ov5640 // or "-d
 basler" for Only basler(CSI1)

# set bootargs
# In serial console, enter into uboot command mode, run below commands:
# If enable basler 4k size, also add androidboot.camera.ispsensor.maxsize=4k.
setenv append_bootconfig androidboot.camera.layout=basler-ov5640
saveenv
boota
```

- Only OV5640 (CSI1) on the host

```
# flash the image
sudo ./fastboot_imx_flashall.sh -f imx8mp -a -e -d ov5640

# set bootargs
# In serial console, enter into uboot command mode, run below command:
```


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```
setenv append_bootconfig androidboot.camera.layout=only-ov5640
saveenv
boota
```

Note:

`-d ov5640` can be replaced by one of below:

`-d lvds`, `-d lvds-panel`, `-d mipi-panel`, `-d mipi-panel-rm67191`, `-d rpmsg`, `-d sof`.

- OS08A20 (CSI1) + OV5640 (CSI2) Or Only OS08A20 (CSI1)

```
# flash the image
sudo ./fastboot_imx_flashall.sh -f imx8mp -a -e -d os08a20-ov5640 # or "-d
 os08a20" for Only os08a20(CSI1)

# set bootargs
# In serial console, enter into uboot command mode, run below commands:
# If enable os08a20 4k size, also add androidboot.camera.ispsensor.maxsize=4k.
setenv append_bootconfig androidboot.camera.layout=os08a20-ov5640
saveenv
boota
```

- Basler (CSI1) + Basler (CSI2)

```
# flash the image
sudo ./fastboot_imx_flashall.sh -f imx8mp -a -e -d dual-basler

# set bootargs
# In serial console, enter into uboot command mode, run below command:
setenv append_bootconfig androidboot.camera.layout=dual-basler
saveenv
boota
```

8.1.4 Switching between single-OS08A20, dual-OS08A20, and AP1302 on i.MX 95 EVK, FRDM-IMX95, i.MX 952 EVK, and FRDM-IMX952

The default `evk_95` and`evk_952` image uses single OS0A20. To make cameras work with Non-default images, perform the following steps:

To use AP1302:

1. Run the following commands:

```
fastboot flash dtbo dtbo-imx95-ap1302.img                # for i.MX 95 EVK
fastboot flash dtbo dtbo-imx95-15x15-frdm-ap1302.img     # for FRDM-IMX95
fastboot flash dtbo dtbo-imx952-ap1302.img               # for i.MX 952 EVK
fastboot flash dtbo dtbo-imx952-frdm-ap1302.img          # for FRDM-IMX952
```

2. In U-Boot command mode, run the following commands:

```
setenv append_bootconfig androidboot.camera.layout=ap1302
saveenv
boot
```

3. Run the following command on the Android console to clear the `Camera2.apk` cached data:

```
pm clear com.android.camera2
```

To use OS0A20 (CSI) + OS0A20 (DSI/CSI):

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1. Run the following commands:

```
# for i.MX 95 EVK, run one of the following 2 commands
fastboot flash dtbo dtbo-imx95-lvds0-dual-os08a20.img
fastboot flash dtbo dtbo-imx95-lvds-dualdisp.img

# for FRDM-IMX95
fastboot flash dtbo dtbo-imx95-15x15-frdm-dual-os08a20.img

# for i.MX 952 EVK, run one of the following 3 commands
fastboot flash dtbo dtbo-imx952-dual-os08a20.img
fastboot flash dtbo-imx952-lvds0-dual-os08a20.img
fastboot flash dtbo-imx952-lvds-dualdisp.img

# for FRDM-IMX952
fastboot flash dtbo dtbo-imx952-frdm.img
```

2. In U-Boot command mode, run the following commands:

```
setenv append_bootconfig androidboot.camera.layout=dual-os08a20       # for
 i.MX 95 EVK and i.MX 952 EVK
setenv append_bootconfig androidboot.camera.layout=frdm-dual-os08a20  # for
 FRDM-IMX95
saveenv
boota
```

3. Run the following command on the Android console to clear the `Camera2.apk` cached data:

```
pm clear com.android.camera2
```

To switch back to single OS0A20:

1. Run the following commands:

```
fastboot flash dtbo dtbo-imx95.img             # for i.MX 95 EVK
fastboot flash dtbo dtbo-imx95-15x15-frdm.img  # for FRDM-IMX95
fastboot flash dtbo dtbo-imx952.img            # for i.MX 952 EVK
```

2. In U-Boot command mode, run the following commands:

```
setenv append_bootconfig
saveenv
boota
```

3. Run the following command on the Android console to clear the `Camera2.apk` cached data:

```
pm clear com.android.camera2
```

8.1.5 Making the AP1302 camera work on i.MX 95 EVK, FRDM-IMX95, i.MX 952 EVK, FRDM-IMX952, and FRDM-IMX937

To make the AP1302 camera work on i.MX 95 EVK, FRDM-IMX95, i.MX 952 EVK, FRDM-IMX952, and FRDM-IMX937, a third-party firmware not included in this release is needed. When trying with the release image, follow the steps below to get the firmware and push it to the device to make the AP1302 work.

1. Remount the filesystems on the device to get the write permission on the vendor partition.
2. Get the AP1302 firmware from: Commit cfdfc8a.

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3. Rename the firmware `NXP_i.MX93/ap1302_60fps_ar0144_27M_2Lane_awb_tuning.bin` to `ap1302_ar0144_single_fw.bin`.
4. Execute the command `adb push ap1302_ar0144_single_fw.bin /vendor/firmware`.
5. Execute the command `adb reboot`.

8.1.6 Making OS08A20 camera work in HDR mode on i.MX 95 EVK, FRDM-IMX95, i.MX 952 EVK, and FRDM-IMX952

To make the OS08A20 camera work in HDR mode on i.MX 95 EVK, FRDM-IMX95, i.MX 952 EVK, and FRDM-IMX952, add the following `boot` command:

```
setenv append_bootconfig androidboot.camera.hdr=true
```

8.1.7 DeviceAsWebcam feature

Android Device as Webcam allows Android devices to act as webcams for laptops and desktops. The feature works by connecting the device to the computer through USB and sending the video data to the computer. This means that users can use their device's camera as a high-quality webcam without having to buy a separate webcam.

The following boards have enabled this feature:

- i.MX 8M Mini EVK Board
- i.MX 8M Nano EVK Board
- i.MX 8M Quad EVK Board
- i.MX 8ULP EVK Board
- i.MX 8QuadMax MEK Board
- i.MX 8QuadXPlus MEK Board
- i.MX 95 EVK and FRDM-IMX95 Boards

Note:

- *This feature requires camera support, so make sure that camera can work properly with the image you flash.*
- *Due to performance limitation, i.MX 8ULP only supports 640 x 480 resolution. Other platforms support MJPG streams at 1920 x 1080 and 1280 x 720 resolutions.*
- *Preview FPS can be checked using `PotPlayerSetup.exe` on Windows. Make sure your USB cable is connected properly.*
- *The preview for OV5640 is always 30 fps, but the reason 30 fps cannot be achieved with this feature is that the encoding takes a lot of time (YUV420SP -> I420 -> MJPG), and the time taken here is related to performance.*

The FPS listed below are for reference.

Table 27. FPS performance of DeviceAsWebcam

Platform	VideoFmt	Resolution	FPS
i.MX 8M Mini	MJPEG	1920 x 1080 1280 x 720	28 fps 30 fps
i.MX 8M Nano	MJPEG	1920 x 1080 1280 x 720	24 fps 30 fps
i.MX 8M Quad	MJPEG	1920 x 1080 1280 x 720	25 fps 30 fps
i.MX 8ULP	MJPEG	640 x 480	30 fps

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Table 27. FPS performance of DeviceAsWebcam*...continued*

Platform	VideoFmt	Resolution	FPS
i.MX 8QuadMax	MJPEG	1920 x 1080 1280 x 720	30 fps 30 fps
i.MX 8QuadXPlus	MJPEG	1920 x 1080 1280 x 720	15 fps 30 fps
i.MX 95	MJPEG	1920 x 1080 1280 x 720	37 fps 60 fps

8.2 Audio configuration

8.2.1 Enabling low-power audio

The `DirectAudioPlayer` application is provided to support audio playback from `DirectOutputThread`. The source code is in `${MY_ANDROID}/vendor/nxp-opensource/fsl_imx_demo/DirectAudioPlayer`. After the `vendor.audio.lpa.enable` property is set to **1**, low-power audio can be enabled. In this situation, audio can keep playing even if the system enters suspending mode.

By default, the music stream plays from `MixedThread`. To make stream play from `DirectOutputThread`, add the `AUDIO_OUTPUT_FLAG_DIRECT` flag to the related tracks. On the Android Application layer, there is no `AUDIO_OUTPUT_FLAG_DIRECT` flag to specify `DirectOutputThread` explicitly. Instead, use `FLAG_HW_AV_SYNC` when there is "new AudioTrack" in the application. Then the Android audio framework adds `AUDIO_OUTPUT_FLAG_DIRECT` for this track, and this stream plays from `DirectOutputThread`.

In low-power audio mode, the default audio period time is 500 milliseconds, and the whole buffer can hold 20 seconds data. These two parameters can be configured by the `vendor.audio.lpa.period_ms` and `vendor.audio.lpa.hold_second` properties as follows:

```
> setprop vendor.audio.lpa.hold_second 20
> setprop vendor.audio.lpa.period_ms 500
```

To enable low-power audio, perform the following steps:

1. Add `-d m4 -m` or `-d rpmsg -m` when flashing images to support audio playback based on MCU FreeRTOS, for example:
   - For i.MX 95: `uuu_imx_android_flash.sh -f imx95 -e -d rpmsg -u rpmsg -m`
   - For i.MX 952: `uuu_imx_android_flash.sh -f imx952 -e -d rpmsg -u rpmsg -m`
   - For i.MX 8M Mini EVK: `uuu_imx_android_flash.sh -f imx8mm -e -d m4 -m`
   - For i.MX 8M Plus EVK: `uuu_imx_android_flash.sh -f imx8mp -e -d rpmsg -m`
   - For i.MX 8ULP EVK: `uuu_imx_android_flash.sh -f imx8ulp -e -d lpa -u trusty-lpa-dual -m`
2. For i.MX 8ULP EVK, set the board boot switch to dual-boot mode: 0100_0001 (SW5, from 1-8 bit). For i.MX 95 EVK, i.MX 952 EVK, i.MX 8M Mini EVK, and i.MX 8M Plus EVK, add `bootmcu` to `bootcmd`.

   ```
   setenv bootcmd "bootmcu && boota"
   ```

3. Add `androidboot.lpa.enable=1` to `append_bootconfig` and `snd_pcm.max_alloc_per_card=134217728` to `append_bootargs` in the U-Boot command line.

   ```
   #For i.MX 95 EVK,i.MX 952 EVK,i.MX 8ULP EVK, i.MX 8M Plus EVK, i.MX 8M Mini
    EVK)
   setenv append_bootconfig androidboot.lpa.enable=1
   ```


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```
# for i.MX 95 EVK, i.MX 952 EVK
setenv append_bootargs snd_pcm.max_alloc_per_card=134217728 pd_ignore_unused
 cma=600M

# for i.MX 8ULP EVK
setenv append_bootargs snd_pcm.max_alloc_per_card=134217728

# for i.MX 8M Plus EVK
setenv append_bootargs snd_pcm.max_alloc_per_card=134217728 clk-
imx8mp.mcore_booted=1

# for i.MX 8M Mini EVK.
setenv append_bootargs snd_pcm.max_alloc_per_card=134217728 clk-
imx8mm.mcore_booted=1

saveenv
```

4. Boot up the system, and push the `.wav` audio files to `/sdcard/`. It is better to use a long-duration audio file.
5. Open the `DirectAudioPlayer` application, and select a file from the spinner. The file selected is listed under the spinner.
6. Click the **Play** button to play audio.
7. Press the ON/OFF button on the board. The system then enters suspend mode, and the audio can keep playing.

Note:

- *Only i.MX 95 EVK, i.MX 952 EVK, i.MX 8M Mini EVK, i.MX 8M Plus EVK, and i.MX 8ULP EVK support this feature.*
  - *For i.MX 8M Mini EVK, the audio is output from the "LPA Output" port on the audio expansion board. See Figure "i.MX 8M Mini EVK with audio board" in the Android Quick Start Guide (UG10157).*
  - *For i.MX 95 EVK, i.MX 95 EVK, i.MX 8M Plus EVK, and i.MX 8ULP EVK, the audio is output from the HEADPHONE jack.*
- *`DirectAudioPlayer` supports limited audio files, which is declared in device's `audio_policy_configuration.xml` with the `AUDIO_OUTPUT_FLAG_DIRECT|AUDIO_OUTPUT_FLAG_HW_AV_SYNC` flag. Other medians are not supported. For example, it does not support playing 44100 Hz audio.*
- *`DirectAudioPlayer` supports 24/32 bits `.wav` file with sampling rates no more than 192000.*

8.2.2 Supporting a new sound card

Perform the following steps to support a new sound card on the Android system:

1. Add a new audio configuration JSON file.
   Each sound card needs one JSON file under the `/vendor/etc/configs/audio` folder of the board, so that Android audio HAL code can manage this card. The content of the JSON file mainly includes the card's driver name, supported output/input device type, and mixer controls that need to be configured.
   See `${MY_ANDROID}/device/nxp/common/audio-json/readme.txt` for details to create such a JSON file. After that, copy the JSON file to the board by the following command in Android makefile:

```
PRODUCT_COPY_FILES += \
```


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```
device/nxp/common/audio-json/xxx_config.json:$(TARGET_COPY_OUT_VENDOR)/etc/
configs/audio/xxx_config.json
```

2. Configure the audio mix port, device port, and route in `${MY_ANDROID}/device/nxp/imx8m/evk_8mp/audio_policy_configuration.xml`.
   - Mix ports describe the possible configuration profiles for streams that can be opened at the audio HAL for playback and capture.
   - Device ports describe the devices that can be attached with their type.
   - Routes describe which mix port can route to which device.

   Take the following configuration as an example. It means that the system supports three output devices: speaker, headphone, and HDMI. If the speaker or headphone is connected, it expects that the frameworks can deliver 16 bit, 48 kHz, and stereo streams to them. If an HDMI device is connected, it expects 24 bit, 48 kHz, and stereo streams.

```
<mixPort name="primary output" role="source"
 flags="AUDIO_OUTPUT_FLAG_PRIMARY">
    <profile name="" format="AUDIO_FORMAT_PCM_16_BIT"
             samplingRates="48000" channelMasks="AUDIO_CHANNEL_OUT_STEREO"/>
</mixPort>
<mixPort name="hdmi output" role="source">
    <profile name="" format="AUDIO_FORMAT_PCM_8_24_BIT"
             samplingRates="48000" channelMasks="AUDIO_CHANNEL_OUT_STEREO"/>
</mixPort>
<devicePort tagName="Speaker" type="AUDIO_DEVICE_OUT_SPEAKER" role="sink" >
</devicePort>
<devicePort tagName="Wired Headphones"
 type="AUDIO_DEVICE_OUT_WIRED_HEADPHONE" role="sink">
</devicePort>
<devicePort tagName="HDMI Out" type="AUDIO_DEVICE_OUT_AUX_DIGITAL"
 role="sink">
</devicePort>
<route type="mix" sink="Speaker"
       sources="primary output"/>
<route type="mix" sink="Wired Headphones"
       sources="primary output"/>
<route type="mix" sink="HDMI Out"
       sources="hdmi output"/>
```

3. (Optional) Support device hot plug.
   Android frameworks support dynamically switching default output device by catching the device's hot-plug event. The uevent can be sent in the kernel by extcon driver.
   a. Declare which device type supports:

```
static const unsigned int xxx_extcon_cables[] = {
   EXTCON_JACK_HEADPHONE,
   EXTCON_NONE,
};
struct extcon_dev xxx_edev;
```

   b. Allocate and register the extcon device:

```
xxx_edev = devm_extcon_dev_allocate(&pdev->dev, xxx_extcon_cables);
devm_extcon_dev_register(&pdev->dev, xxx_edev);
```


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c. When the device is connected, execute the following command to tell frameworks that the headphone device has been connected:

```
extcon_set_state_sync(extcon_dev, EXTCON_JACK_HEADPHONE, 1);
```

d. When the device is disconnected, execute the following command:

```
extcon_set_state_sync(extcon_dev, EXTCON_JACK_HEADPHONE, 0).
```

8.2.3 Enabling powersave mode

By default, the DRAM speed is 4000 MT/s, the GIC frequency is 500 MHz, and VDD_SOC is 0.95 V. A powersave mode can be achieved with the following conditions:

- DRAM speed is 2400 MT/s.
- VDD_SOC is 0.85 V.
- Prohibit the eMMC module, FEC module, BT module, and Wi-Fi module from requesting high bus frequency.
- Disable LDB, ISP, and HDMI.
- USB power domain is active when the USB is in use, and enters suspending when the USB is not in use.
- When playing local audio and output with Bluetooth headset, playing local audio through LPA and output with wired headset, playing online audio and output with wired headset at the time of screen off, the DRAM speed is 400 MT/s and the GIC frequency is 100 MHz.

Perform the following steps to enable powersave mode:

1. Setup the gcc toolchain. If you have downloaded the AArch32 toolchain in Section 3.2, export the toolchain path `ARMGCC_DIR` variable as `export ARMGCC_DIR=/opt/arm-gnu-toolchain-12.3.rel1-x86_64-arm-none-eabi`. The toolchain path can vary based on your actual toolchain path, you can add the export command to `/etc/profile` so it can be used directly when host boot up.
2. Upgrade the CMake version to or higher than 3.13.0. If the CMake version on your machine is not higher than 3.13.0, you can execute the following commands to upgrade it:

```
wget https://github.com/Kitware/CMake/releases/download/v3.13.2/
cmake-3.13.2.tar.gz
tar -xzvf cmake-3.13.2.tar.gz; cd cmake-3.13.2;
sudo ./bootstrap
sudo make
sudo make install
```

3. Build image with `POWERSAVE=true`.

```
POWERSAVE=true ./imx-make.sh -j4 2>&1 | tee build-log.txt
```

Perform the following steps to play audio in powersave mode with the MCU image:

1. Use `-u trusty-powersave-dual -d powersave-non-rpmsg -m` when flashing images to enable powersave mode, for example:

```
# For imx8mp
sudo uuu_imx_android_flash.sh -f imx8mp -e -u trusty-powersave-dual -d
 powersave-non-rpmsg -m
```

2. Set `bootargs` in U-Boot command line:

```
setenv append_bootconfig androidboot.lpa.enable=1
```


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```
setenv append_bootargs snd_pcm.max_alloc_per_card=134217728 clk-
imx8mp.mcore_booted=1
saveenv
```

3. Set `bootcmd` in U-Boot command line:

```
setenv bootcmd "bootmcu && boota"
saveenv
```

Make sure that only "MIPI DSI", "Debug UART", and "Power" ports are connected on the board.

4. To play local audio through LPA and output with wired headset:
   a. Boot up the system.
   b. Push the `.wav` audio files to `/sdcard/`. It is better to use a long duration audio file.
   c. Open the DirectAudioPlayer application. Select a file from the spinner, and the file selected is listed under the spinner.
   d. Click the Play button to play audio.
   e. Press the power key on the board to make the system enter suspend mode, and the audio can keep playing.

Perform the following steps to play audio in powersave mode without the MCU image:

1. Use `-u trusty-powersave -d powersave-non-rpmsg4` when flashing images to enable the powersave mode, for example:

```
# For imx8mp
sudo uuu_imx_android_flash.sh -f imx8mp -e -u trusty-powersave -d powersave-
non-rpmsg
```

Make sure that only "MIPI DSI", "Debug UART", and "Power" ports are connected on the board.

2. To play audio and output with Bluetooth headset:
   a. Boot up the system.
   b. Push the `.mp3` audio files to `/sdcard/`. It is better to use a long-duration audio file.
   c. Connect a Bluetooth headset.
   d. Play the `.mp3` audio file and turn off the screen.
3. To play online audio and output with wired headset:
   a. Boot up the system.
   b. Connect to the Wi-Fi access point.
   c. Open the Spotify application and play audio and turn off the screen.

Note: *Only the i.MX 8M Plus EVK Board supports this feature.*

8.3 Display configuration

8.3.1 Configuring the logical display density

The Android UI framework defines a set of standard logical densities to help application developers target application resources.

Device implementations must report one of the following logical Android framework densities:

- 120 dpi, known as 'ldpi'
- 160 dpi, known as 'mdpi'
- 213 dpi, known as 'tvdpi'
- 240 dpi, known as 'hdpi'

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- 320 dpi, known as 'xhdpi'
- 480 dpi, known as 'xxhdpi'

Device implementations should define the standard Android framework density that is numerically closest to the physical density of the screen, unless that logical density pushes the reported screen size below the minimum supported.

The default display density value is defined as 240 dpi. It can be changed to a different value by modifying the default `ro.sf.lcd_density` property under `${MY_ANDROID}/device/nxp/`. For example:

```
on property:ro.boot.lcd_density=""
    setprop ro.sf.lcd_density 160
```

The density can also be changed by setting the U-Boot environment variable `setenv append_bootconfig androidboot.lcd_density=160` for development purposes.

Note:

- *For the i.MX 8M Mini EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8m/evk_8mm/BoardConfig.mk`.*
- *For the i.MX 8M Nano EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8m/evk_8mn/BoardConfig.mk`.*
- *For the i.MX 8M Plus EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8m/evk_8mp/BoardConfig.mk`.*
- *For the i.MX 8M Quad WEVK/EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8m/evk_8mq/BoardConfig.mk`.*
- *For the i.MX 8ULP EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8ulp/evk_8ulp/BoardConfig.mk`.*
- *For the i.MX 8QuadMax/8QuadXPlus MEK board, the source folder is `${MY_ANDROID}/device/nxp/imx8q/mek_8q/BoardConfig.mk`.*
- *For the i.MX 95 EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx9/evk_95/BoardConfig.mk`.*
- *For the i.MX 952 EVK and FRDM-IMX952 boards, the source folder is `${MY_ANDROID}/device/nxp/imx9/evk_952/BoardConfig.mk`.*
- *For the FRDM-IMX937 board, the source folder is `${MY_ANDROID}/device/nxp/imx9/frdm_937/BoardConfig.mk`.*

8.3.2 Enabling multiple-display function

The following boards support more than one display.

Table 28. Boards supporting multiple displays

Board	Number of displays	Display port
i.MX 8QuadMax MEK	4	• If physical HDMI is used: HDMI_TX, LVDS0_CH0, LVDS1_CH0, and MIPI_DSI1 • If physical HDMI is not used: LVDS0_CH0 and LVDS1_CH0, MIPI_DSI0, and MIPI_DSI1
i.MX 8QuadXPlus MEK	2	DSI0/LVDSI0, DSI1/LVDSI1
i.MX 8M Quad WEVK/EVK	2	HDMI, MIPI-DSI-to-HDMI
i.MX 8M Plus EVK	3	MIPI-DSI, LVDS0, HDMI
i.MX 95 EVK	2	• If MIPI-to-HDMI is used: MIPI-to-HDMI and LVDS1

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Table 28. Boards supporting multiple displays*...continued*

Board	Number of displays	Display port
		• If MIPI-to-HDMI is not used: LVDS0 and LVDS1
i.MX 952 EVK	2	LVDS0 and LVDS1

The two displays on i.MX 8QuadXPlus MEK are enabled by default.

The three displays on i.MX 8M Plus EVK are enabled by default.

To evaluate the multiple-display feature with physical HDMI on i.MX 8QuadMax MEK, flash `dtbo-imx8qm-md.img`. It implies a limitation of the resolution of the physical HDMI. To use multiple displays, do not use the physical HDMI with the resolution of 4K.

To evaluate the multiple-display feature on i.MX 8MQuad EVK, flash `dtbo-imx8mq-dual.img`.

To evaluate the multiple display feature on i.MX 95 EVK, flash `dtbo-imx95-lvds-dualdisp.img` or `dtbo-imx95-mipi-lvds1.img`.

To evaluate the multiple displays feature on i.MX 952 EVK, flash `dtbo-imx952-lvds-dualdisp.img`.

8.3.2.1 Binding the display port with the input port

The display port and input port are bound together based on the input device location and display-ID. `/vendor/etc/input-port-associations.xml` is used to do this work when the system is running, but the input device location and display-ID changes with the change of connection forms of these ports with corresponding input and display devices, which means the input location and display-ID need to be retrieved before the connection is fixed.

The source file of `/vendor/etc/input-port-associations.xml` is in the repository under the `${MY_ANDROID}/device/nxp/` directory.

Take i.MX 8M Plus EVK as an example:

1. Use the following commands to obtain the display port number:

```
dumpsys SurfaceFlinger --display-id
Display 4693505326422272 (HWC display 0): port=0 pnpId=DEL displayName="DELL
 P2314T"
Display 4693505326422273 (HWC display 1): port=1 pnpId=DEL displayName="DELL
 P2314T"
Display 4692921138614786 (HWC display 2): port=2 pnpId=DEL displayName="DELL
 S2740L"
```

2. Use the following commands to obtain the touch input location:

```
getevent -i | grep location
location: "usb-xhci-hcd.0.auto-1.3.4/input0"
location: "usb-xhci-hcd.0.auto-1.2.4/input0"
location: "usb-xhci-hcd.0.auto-1.1.4/input0"
```

3. Bind the display port and input location as follows and modify the configuration file. This file needs to be modified according to actual connection. One display port can be bound with multiple input ports.

```
<ports>
    <port display="0" input="usb-xhci-hcd.0.auto-1.1.4/input0" />
    <port display="1" input="usb-xhci-hcd.0.auto-1.2.4/input0" />
    <port display="2" input="usb-xhci-hcd.0.auto-1.3.4/input0" />
</ports>
```


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To make the modifications take effect, modify the source file under the `${MY_ANDROID}/device/nxp/` directory and rebuild the images. Keep the connection of display devices and input devices unchanged and reflash the images. Or you can disable DM-verity on the board and then use the `adb push` command to push the file to the vendor partition to overwrite the original one.

8.3.2.2 Configuring the display topology

There are two ways to configure multi-display topology to customize the positional relationships of multiple displays. Similar to the PC, different display topologies allow the mouse to move to other display from different directions. By system default, the second non-primary display is above the primary display, and the third non-primary display is to the right of the primary display.

- First way (runtime): After multiple screens are connected, perform the following UI steps to enter the configuration screen to configure the display topology.

```
Enter Settings -> Connected devices -> Other devices -> External displays
```

- Second way: This way applies to configure the default topology after device bootup and can be overridden by runtime way. `/vendor/etc/displayconfig/display_topology.xml` is used to do this work when the system is running.

The source file of `/vendor/etc/displayconfig/display_topology.xml` is in the repository under the `${MY_ANDROID}/device/nxp/` directory.

Take i.MX 8M Plus EVK as an example:

1. Use the following `adb` shell commands to get the display unique ID:

```
dumpsys display | grep mUniqueId
mUniqueId=local:4616379398377183233
mUniqueId=local:4616379523753810178
mUniqueId=local:4616379523753810179
```

2. Then, configure the display topology and modify the configuration file. This file needs to be modified according to the actual requirements. The following is an example of the vendor configuration, which overrides the system default topology. In this example, the two non-primary displays are placed to the right and left of the primary display, respectively.

```
<?xml version="1.0" encoding="utf-8"?>
<displayTopologyState version="1">
    <topology id="internal|local:4616379523753810178|
local:4616379523753810179" order="0">
    <display id="internal" primary="true">
        <position>left</position>
        <offset>0.0</offset>
        <children>
            <display id="local:4616379523753810178">
                <position>right</position>
                <offset>0.0</offset>
                <children/>
            </display>
            <display id="local:4616379523753810179">
                <position>left</position>
                <offset>0.0</offset>
                <children/>
            </display>
        </children>
    </display>
    </topology>
```


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```
</displayTopologyState>
```

Note:

In the configuration file, the primary display does not need to be configured with a display ID. However, in the `<topology id="internal|local:4616379523753810178|local:4616379523753810179" order="0">` *entry, the display ID of each non-primary display should be listed sequentially using the* `|` *symbol, and all display IDs should be sorted in ascending lexicographical order as Java strings. Both the* `position` *and* `offset` *fields are relative to the parent node.* `position` *can be set* `left`*,* `right`*,* `top`*, or* `bottom`*.* `offset` *can be set positive or negative value. For the left/right position, the offset value means that the top edge of the child display is lower than the top edge of the parent display. For the top/bottom position, the offset value means that the left side of the child display is more to the right than the left side of the parent display.*

8.3.2.3 Launching applications on different displays

When multiple displays are connected, applications can be opened in desktop mode by default on the non-primary display.

8.3.3 Enabling low-power display function

Currently, only the i.MX 8ULP EVK board supports the low-power display function. This demo demonstrates the shared display switching between the Application domain (APD) and the Realtime domain (RTD). It provides a possible solution for smart watch to optimize power consumption when the screen is on.

8.3.3.1 Enabling low-power display on i.MX 8ULP EVK

Perform the following steps to enable the low-power display:

1. As the dual-boot mode is used to enable the low-power display feature, the MCU image should be built and flashed separately. Add `-u trusty-dualboot-dual -d lpd -m` when flashing images to flash image separately, for example:

   ```
   uuu_imx_android_flash.sh -f imx8ulp -e -u trusty-dualboot-dual -d lpd -m
   ```

2. To update the MCU binary only, use the UUU script to flash the MCU image only:

   ```
   uuu_imx_android_flash.sh -f imx8ulp -u trusty-dualboot-dual -m
   ```

3. After flashing the image, set the board boot switch to dual-boot mode to boot up the board normally: `0100_0001(SW5, from 1-8 bit).`

8.3.3.2 Some test commands in low-power display demo

This feature on the MCU side is based on FreeRTOS and the console function is added to test this feature easily.

- When the system boots up, this feature works as the default behavior (described in next section). Use the following command to switch to the `auto sleep` behavior:

  ```
  autosleep 10
  ```

  The RTD UI turns off after 10 seconds (this value should be larger than 0). To disable this behavior, just input `autosleep 0` to switch to the default behavior.
- The backlight of the RTD UI can be adjusted by the following commands:

  ```
  adjust backlight to maximum: bl 100
  ```


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```
turn off backlight: bl 0
```

8.3.3.3 Test procedure for low-power display demo

Default behavior

When the system boots up, this low-power display works as the default behavior.

- When the Android system boots up, make Android enter SUSPEND mode (remove the USB, press the ON/OFF button). Then RTD takes over the display and shows the watch dial and updates the time all the time.
- Press the ON/OFF button again to resume the Android system. APD takes over the display again and shows the Android UI.

Note: *Sometimes the alarm wakes up APD, but does not light up the Android UI. The screen keeps dialing, and then updates the time again when APD suspends again.*

Auto Sleep behavior

The UART console on the MCU side supports to input some commands to make RTD UI (watch dial) turn off in some time. Press the RTD BUTTON1 (Vol+) to show the dial again. If such a button is pressed when the RTD UI is showing, it wakes up APD and shows the Android UI. When the Android UI is showing, press RTD BUTTON1 (Vol+), which can make the Android audio volume up.

- Input `autosleep 10` to make the RTD UI turn off in 10s. `autosleep 0` disables such behavior.
- When the display is turned off, pressing RTD BUTTON1 makes the RTD UI show again. It turns off the display again if there is no other action.
- When the RTD UI (dial) is showing, pressing RTD BUTTON1 wakes up APD and shows the Android UI.
- When the Android UI is showing, pressing RTD BUTTON1 works as the Vol+ button.

Note: *When the auto sleep feature is enabled, only RTD BUTTON1 can make the RTD UI show again (APD in suspend mode).*

8.3.4 HDMI-CEC feature

Consumer Electronics Control (CEC) is a feature of HDMI designed to allow users to command and control devices connected through HDMI by using only one remote control.

8.3.4.1 Implementation on i.MX platforms

Before the test, you need to know the following:

- Currently, only the platforms with physical HDMI support this feature, so the feature is enabled on i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8M Plus EVK boards. Pay attention to the images flashed.

```
./fastboot_imx_flashall.sh -f imx8mq -a -e -u trusty-dual
./fastboot_imx_flashall.sh -f imx8qm -a -e -u hdmi -d hdmi
./fastboot_imx_flashall.sh -f imx8mp -a -e -u trusty-dual
```

- TV input is restricted to HDMI1. Other connector port inputs are not supported.
- For i.MX 8QuadMax, TV input is restricted to HDMI1, and other input ports are not supported.
- For i.MX 8M Quad, multiple TV input ports are supported, but hot-plug between multiple ports is not supported.
- For i.MX 8M Plus, multiple TV input ports are supported, and hot-plug between multiple ports is supported.
- Most TVs and devices support HDMI-CEC, but it may be referred to by different branded trade names, so check your device's settings to enable it. For most TVs, there is a CEC-related introduction for your reference.
- An i.MX 8 device acts as a playback device (logical address 4).

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8.3.4.2 Test procedure for HDMI-CEC End-User features

Not all End-User features are supported (One Touch Play, System Standby are definitely supported), and some features involve whether the TV remote control provides commands (Deck Control, Device Menu Control, Remote Control Pass Through).

Ensure that the device boots up and the TV displays the HOME UI properly.

Table 29. Test procedure for HDMI-CEC End-User features

CEC End-User feature	Test step
One Touch Play	1. Set TV to other display (the HDMI connector is not actually connected to the Internet TV). 2. Press the **on** button. Then the TV switches to the relevant HDMI connector and display.
System Standby	1. Press the device **off** button. Then the TV enters the standby state. You can check the TV state by the TV remote control: Press the **standby** button. Then the TV recovers from the standby state, which means that it truly entered into standby. 2. Press the device **on** button. Then the TV exits the standby state. ***Note:*** *Only device control TV is supported, and TV control device is not supported.*
Deck Control	Media functions: 1. Prepare a test video (or record a video through camera), opened by **Gallery**. 2. Perform **Play** and **Pause** video playback through TV remote control. ***Note:*** *Other commands, such as fast forward, rewind, and stop, are not supported.*
Device Menu Control	Use your TV remote control to navigate the menu settings on a connected source device. 1. **Contents** Menu: Open **Gallery**, and then press **content list**. The menu is then displayed in the current view. 2. **Home** Menu: On other displays (enter an `apk` or `swipe up` to open the detailed application menu), press **Home**. The system returns to the HOME UI. ***Note:*** *The operations depend on whether the TV remote control has these buttons. Other menus were not tested.*
Remote Control Pass Through	Select; Up; Down; Left; Right; Exit; 0 1 2... 1. Run `swipe up` to open the detailed application menu. 2. Use TV remote control to move the cursor to select the application and enter the application, or Exit the application. ***Note:*** *The operations depend on whether the TV remote control has these buttons. Other commands were not tested.*
One touch Record	It is not supported, and it needs to be used as a recording device.
Timer Programming	It is not supported, and it needs to be used as a recording device.
Tuner Control	It is not supported, and it needs to be used as a tuner device.
System Audio Control	It is not supported, and it needs to be used as an audio system.

8.3.5 Enabling Virtual Display on HWC 2D composition

To enable the virtual display on HWC 2D composition, some code updates are required. Taking i.MX 8M Mini as an example, apply the following changes under `${MY_ANDROID}/device/nxp`:

```
diff --git a/imx8m/evk_8mm/evk_8mm.mk b/imx8m/evk_8mm/evk_8mm.mk
index e533ab378..aa9458ba4 100644
--- a/imx8m/evk_8mm/evk_8mm.mk
+++ b/imx8m/evk_8mm/evk_8mm.mk
@@ -311,6 +311,10 @@ PRODUCT_DEFAULT_PROPERTY_OVERRIDES += \
 PRODUCT_DEFAULT_PROPERTY_OVERRIDES += \
```


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```
 ro.surface_flinger.game_default_frame_rate_override=60
+# force RGBA->YUV conversion in HWC
+PRODUCT_DEFAULT_PROPERTY_OVERRIDES += \
+ ro.surface_flinger.force_hwc_copy_for_virtual_displays=true
+
 # Gralloc HAL
 PRODUCT_PACKAGES += \
 android.hardware.graphics.allocator-service.imx \
diff --git a/imx8m/evk_8mm/init.rc b/imx8m/evk_8mm/init.rc
index 4dddef46c..cd269fd90 100644
--- a/imx8m/evk_8mm/init.rc
+++ b/imx8m/evk_8mm/init.rc
@@ -19,6 +19,8 @@ on early-init
 # Disable edge extension shader cache
 setprop debug.sf.prime_shader_cache.edge_extension_shader false
+ # Enable virtual display in HWC
+ setprop debug.sf.enable_hwc_vds 1
 # Skip charger_not_need trigger for charger mode
 on early-init && property:ro.boot.mode=charger
```

8.4 Wi-Fi/Bluetooth configuration

8.4.1 Enabling or disabling Bluetooth profile

Default enabled Bluetooth profiles for Android build are configured in files named `product.prop` which can be found under `${MY_ANDROID}/device/nxp/`.

For example, `bluetooth.profile.asha.central.enabled?=false` indicates that the ASHA profile is disabled. `bluetooth.profile.a2dp.source.enabled?=true` indicates that the A2DP profile is enabled.

To change enabled Bluetooth profiles, change the default Bluetooth profile configuration.

The following is an example to set ASHA enabled and A2DP disabled for the i.MX 8M Mini board.

The file to be changed is `${MY_ANDROID}/device/nxp/imx8m/evk_8mm/product.prop`.

```
bluetooth.profile.asha.central.enabled?=true
bluetooth.profile.a2dp.source.enabled?=false
```

8.5 USB configuration

8.5.1 Enabling USB 2.0 in U-Boot for i.MX 8QuadMax/8QuadXPlus MEK

There are both USB 2.0 and USB 3.0 ports on i.MX 8QuadMax/8QuadXPlus MEK board. Because U-Boot can support only one USB gadget driver, the USB 3.0 port is enabled by default. To use the USB 2.0 port, modify the configurations to enable it and disable the USB 3.0 gadget driver.

For i.MX 8QuadMax, to enable USB 2.0 for the `u-boot-imx8qm.imx`, make the following changes under `${MY_ANDROID}/vendor/nxp-opensource/uboot-imx:`

```
diff --git a/configs/imx8qm_mek_android_defconfig b/configs/imx8qm_mek_android_defconfig
index fec2840430..c1c963bef3 100644
--- a/configs/imx8qm_mek_android_defconfig
+++ b/configs/imx8qm_mek_android_defconfig
@@ -136,7 +136,7 @@ CONFIG_SPL_PHY=y
CONFIG_SPL_USB_GADGET=y
```


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```
CONFIG_SPL_USB_SDP_SUPPORT=y
-CONFIG_SPL_SDP_USB_DEV=1
+CONFIG_SPL_SDP_USB_DEV=0
CONFIG_SDP_LOADADDR=0x80400000
CONFIG_FASTBOOT=y
@@ -147,7 +147,7 @@ CONFIG_FASTBOOT_UUU_SUPPORT=n
CONFIG_FASTBOOT_BUF_ADDR=0x98000000
CONFIG_FASTBOOT_BUF_SIZE=0x19000000
CONFIG_FASTBOOT_FLASH=y
-CONFIG_FASTBOOT_USB_DEV=1
+CONFIG_FASTBOOT_USB_DEV=0
CONFIG_BOOTAUX_RESERVED_MEM_BASE=0x88000000
CONFIG_BOOTAUX_RESERVED_MEM_SIZE=0x01000000
diff --git a/include/configs/imx8qm_mek_android.h b/include/configs/imx8qm_mek_android.h
index 1fb6b45768..c60f924f02 100644
--- a/include/configs/imx8qm_mek_android.h
+++ b/include/configs/imx8qm_mek_android.h
@@ -19,7 +19,6 @@
#define IMX_HDMITX_FIRMWARE_SIZE 0x20000
#define IMX_HDMIRX_FIRMWARE_SIZE 0x20000
-#define CONFIG_FASTBOOT_USB_DEV 1
#undef CONFIG_EXTRA_ENV_SETTINGS
#undef CONFIG_BOOTCOMMAND
```

For i.MX 8QuadXPlus, to enable USB 2.0 for the `u-boot-imx8qxp.imx`, make the following changes under `${MY_ANDROID}/vendor/nxp-opensource/uboot-imx:`

```
diff --git a/configs/imx8qxp_mek_android_defconfig b/configs/imx8qxp_mek_android_defconfig
index 2dbd3f3f91..57aec56b0c 100644
--- a/configs/imx8qxp_mek_android_defconfig
+++ b/configs/imx8qxp_mek_android_defconfig
@@ -138,7 +138,7 @@ CONFIG_SPL_PHY=y
CONFIG_SPL_USB_GADGET=y
CONFIG_SPL_USB_SDP_SUPPORT=y
-CONFIG_SPL_SDP_USB_DEV=1
+CONFIG_SPL_SDP_USB_DEV=0
CONFIG_SDP_LOADADDR=0x80400000
CONFIG_FASTBOOT=y
@@ -149,7 +149,7 @@ CONFIG_FASTBOOT_UUU_SUPPORT=n
CONFIG_FASTBOOT_BUF_ADDR=0x98000000
CONFIG_FASTBOOT_BUF_SIZE=0x19000000
CONFIG_FASTBOOT_FLASH=y
-CONFIG_FASTBOOT_USB_DEV=1
+CONFIG_FASTBOOT_USB_DEV=0
CONFIG_SYS_I2C_IMX_VIRT_I2C=y
CONFIG_I2C_MUX_IMX_VIRT=y
diff --git a/include/configs/imx8qxp_mek_android.h b/include/configs/imx8qxp_mek_android.h
index 7e70e92f49..d8e420114f 100644
--- a/include/configs/imx8qxp_mek_android.h
+++ b/include/configs/imx8qxp_mek_android.h
@@ -16,8 +16,6 @@
#define FSL_FASTBOOT_FB_DEV "mmc"
-#define CONFIG_FASTBOOT_USB_DEV 1
-
#undef CONFIG_EXTRA_ENV_SETTINGS
#undef CONFIG_BOOTCOMMAND
```

More than one `defconfig` files are used to build U-Boot images for one platform. Make the same changes on `defconfig` files as above to enable USB 2.0 for other U-Boot images. You can use the following command under the `${MY_ANDROID}/vendor/nxp-opensource/uboot-imx/` directory to list all the related `defconfig` files:

```
ls configs | grep "imx8q.*android.*"
```

8.5.2 Changing the VID/PID values of the USB Gadget

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8.5.2.1 USB Gadget in U-Boot

The USB Gadget functions in the U-Boot stage include fastboot and SPL Serial Download Protocol (SDP).

The VID/PID values for fastboot are **0x1fc9/0x0152**, they are configured with two `defconfig` items as follows. They can be found in the `defconfig` file.

```
CONFIG_USB_GADGET_VENDOR_NUM=0x1fc9
CONFIG_USB_GADGET_PRODUCT_NUM=0x0152
```

The VID/PID values for SPL SDP are **0x1fc9/0x0151**. The VID value is the same as before, and the PID value is changed to **0x0151** with the following function. The corresponding source code file is `${MY_ANDROID}/vendor/nxp-opensource/uboot-imx/arch/arm/mach-imx/spl.c`.

```
int g_dnl_bind_fixup(struct usb_device_descriptor *dev, const char *name)
{
    put_unaligned(0x0151, &dev->idProduct);
    return 0;
}
```

The UUU tool relies on the VID/PID value, the reference values can be found in the UUU source code config.cpp. Therefore, if the values are changed, UUU may not work. But the U-Boot image used with UUU is not flashed to the board, so the one in prebuilt images can be used during development if the VID/PID values need to be changed.

8.5.2.2 USB Gadget on the Android platform

There are many VID/PID value sets on the Android platform. They are set in the USB Gadget HAL with the following function. The corresponding source code file is `${MY_ANDROID}/vendor/nxp-opensource/imx/usb/gadget/aidl/UsbGadget.cpp`. Search for the name of the following function in the source code file. Different PID/VID values are used when the Gadget provides different functions. Change the values based on your requirement.

```
static Status setVidPid(const char *vid, const char *pid)
```

8.5.2.3 USB Gadget in Recovery

The USB Gadget functions in Recovery include `adb` and `fastbootd`. The VID/PID values are set in `${MY_ANDROID}/bootable/recovery/etc/init.rc`. The following lines can be found in the file:

```
write /config/usb_gadget/g1/idVendor 0x18D1
write /config/usb_gadget/g1/idProduct 0xD001
write /config/usb_gadget/g1/idProduct 0x4EE0
```

Change the value in preceding lines based on your requirement.

8.6 Trusty OS/security configuration

Trusty OS firmware is used in this i.MX Android release as TEE, which supports security features.

The i.MX Trusty OS is based on the AOSP Trusty OS and supports the i.MX 8M Mini EVK, i.MX 8M Nano EVK, i.MX 8M Plus EVK, i.MX 8M Quad EVK, i.MX 8ULP EVK, i.MX 8QuadMax MEK, i.MX 8QuadXplus MEK, i.MX 95 EVK, FRDM-IMX95, i.MX 952 EVK, FRDM-IMX952, and FRDM-IMX937 boards. This section provides some basic configurations to make Trusty OS work on the EVK/MEK boards. For more configurations about security-related features, see the *i.MX Android Security User's Guide* (UG10158).

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Customers can modify the Trusty OS code to make different configurations and enable different features. The Trusty OS binaries can be built by following the commands below:

```
$ cd ${MY_ANDROID}
$ source trusty/vendor/google/aosp/scripts/envsetup.sh
$ ./trusty/vendor/google/aosp/scripts/build.py imx8mm #i.MX 8M Mini EVK Board
$ cp build-root/build-imx8mm/lk.bin vendor/nxp/fsl-proprietary/uboot-firmware/
imx8m/tee-imx8mm.bin

# confirmationui.app was build as loadable app
$ cp build-root/build-imx8mm/user_tasks/trusty/user/app/confirmationui/
confirmationui.app \
     vendor/nxp/fsl-proprietary/uboot-firmware/imx8m/confirmationui-imx8mm.app
```

Then, build the Android images. The `tee-imx8mm.bin` and loadable `confirmationui.app` would be packaged into the final Android images.

Note:

- *For i.MX 8M Nano EVK, use parameter `imx8mn` to build the Trusty OS image. Then copy the files `lk.bin` and `confirmationui.app` to `vendor/nxp/fsl-proprietary/uboot-firmware/imx8m/tee-imx8mn.bin` and `vendor/nxp/fsl-proprietary/uboot-firmware/imx8m/confirmationui-imx8mn.app`.*
- *For i.MX 8M Plus EVK, use the parameter `imx8mp` to build the Trusty OS image. Copy the files `lk.bin` and `confirmationui.app` to `vendor/nxp/fsl-proprietary/ uboot-firmware/tee-imx8mp.bin` and `vendor/nxp/fsl-proprietary/uboot-firmware/imx8m/confirmationui-imx8mp.app`.*
- *For i.MX 8M Quad EVK, use the parameter `imx8m` to build the Trusty OS image. Copy the files `lk.bin` and `confirmationui.app` to `vendor/nxp/fsl-proprietary/uboot-firmware/imx8m/tee-imx8mq.bin` and `vendor/nxp/fsl-proprietary/uboot-firmware/imx8m/confirmationui-imx8mq.app`.*
- *For i.MX 8ULP EVK, use the parameter `imx8ulp` to build the Trusty OS image. Copy the file `lk.bin` to `vendor/nxp/fsl-proprietary/uboot-firmware/imx8ulp/tee-imx8ulp.bin` and `vendor/nxp/fsl-proprietary/uboot-firmware/imx8ulp/confirmationui-imx8ulp.app`.*
- *For i.MX 8QuadMax MEK, use the parameter `imx8qm` to build the Trusty OS image. Copy the file `lk.bin` to `vendor/nxp/fsl-proprietary/uboot-firmware/imx8q_car/tee-imx8qm.bin`.*
- *For i.MX 8QuadXPlus MEK, use the parameter `imx8qxp` to build the Trusty OS image. Copy the file `lk.bin` to `vendor/nxp/fsl-proprietary/uboot-firmware/imx8q_car/tee-imx8qx.bin`.*
- *For i.MX 95 EVK and FRDM-IMX95, use the parameter `imx95` to build the Trusty OS image. Copy the files `lk.bin` and `confirmationui.app` to `vendor/nxp/fsl-proprietary/uboot-firmware/imx9/tee-imx95.bin` and `vendor/nxp/fsl-proprietary/uboot-firmware/imx95/confirmationui-imx95.app`.*
- *For i.MX 952 EVK and FRDM-IMX952, use the parameter `imx952` to build the Trusty OS image. Copy the files `lk.bin` and `confirmationui.app` to `vendor/nxp/fsl-proprietary/uboot-firmware/imx952/tee-imx952.bin` and `vendor/nxp/fsl-proprietary/uboot-firmware/imx952/confirmationui-imx952.app`.*
- *For FRDM-IMX937, use parameter `imx937` to build the Trusty OS image. Copy the files `lk.bin` and `confirmationui.app` to `vendor/nxp/fsl-proprietary/uboot-firmware/imx937/tee-imx937.bin` and `vendor/nxp/fsl-proprietary/uboot-firmware/imx937/confirmationui-imx937.app`.*
- *`${MY_ANDROID}` is the root directory of the Android codebase.*

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8.6.1 Initializing the secure storage for Trusty OS

Trusty OS uses the secure storage to protect userdata. This secure storage is based on RPMB on the eMMC chip. RPMB needs to be initialized with a key, and default execution flow of images does not make this initialization.

Initialize the RPMB with hardware bound key or vendor specified key are both supported. The RPMB key cannot be changed once it is set.

- To set a **hardware bound** key, perform the following operation:
  Make your board enter fastboot mode, and then execute the following command on the host side:

```
fastboot oem set-rpmb-hardware-key
```

  After the board is rebooted, the RPMB service in Trusty OS is initialized successfully.

- To set a **vendor specified** key, perform the following operation:
  Make your board enter fastboot mode, and then execute the following commands on the host side:

```
fastboot stage < path-to-your-rpmb-key >
fastboot oem set-rpmb-staged-key
```

  After the board is rebooted, the RPMB service in the Trusty OS is initialized successfully.
  Note:
  – *This method does not work on the platforms without CAAM (for example, i.MX 95).*
  – *The RPMB key should start with magic "RPMB" and be followed with 32 bytes hexadecimal key.*
  – *A prebuilt `rpmb_key_test.bin` whose key is fixed 32 bytes hexadecimal 0x00 is provided. It is generated with the following shell commands:*

    –
```
touch rpmb_key_test.bin
```

    –
```
echo -n "RPMB" > rpmb_key_test.bin
```

    –
```
echo -n -e '\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00' >> rpmb_key_test.bin
```

  The `\xHH` means eight-bit character whose value is the hexadecimal value 'HH'. You can replace "00" above with the key you want to set.

- ***Note:***
  For more details, see the i.MX Android Security User's Guide (UG10158).

8.6.2 Provisioning the AVB key

The AVB key consists of public key and private key. The private key is used by the host to sign the vbmeta struct in vbmeta image, and the public key is used by AVB to authenticate the vbmeta image. The following figure shows the relationship between the private key, public key, and vbmeta image. Without Trusty OS, the public key is hard-coded in U-Boot, while with Trusty OS, it is saved in secure storage.

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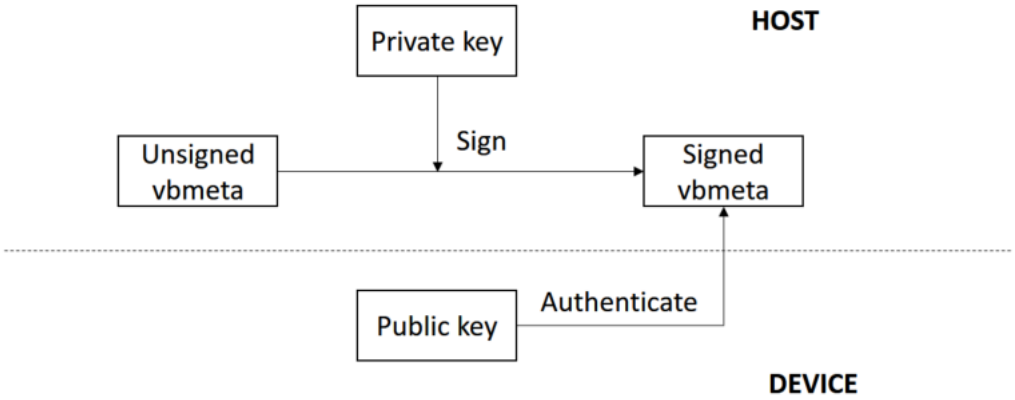


Figure 2. Relationship between AVB key and vbmeta

8.6.2.1 Generating the AVB key to sign images

OpenSSL provides some commands to generate the private key. For example, you can use the following commands to generate the RSA-4096 private key `test_rsa4096_private.pem`:

```
openssl genpkey -algorithm RSA -pkeyopt rsa_keygen_bits:4096 -outform PEM -out
 test_rsa4096_private.pem
```

The public key can be extracted from the private key. The avbtool in `${MY_ANDROID}/external/avb` supports such commands. You can get the public key `test_rsa4096_public.bin` with the commands:

```
avbtool extract_public_key --key test_rsa4096_private.pem --output
 test_rsa4096_public.bin
```

By default, the Android build system uses the algorithm SHA256_RSA4096 with the private key from `${MY_ANDROID}/external/avb/test/data/testkey_rsa4096.pem`. This can be overwritten by setting the `BOARD_AVB_ALGORITHM` and `BOARD_AVB_KEY_PATH` to use different algorithm and private key:

```
BOARD_AVB_ALGORITHM := <algorithm-type>
BOARD_AVB_KEY_PATH := <key-path>
```

Algorithm SHA256_RSA4096 is recommended. The Android build system signs the vbmeta struct in vbmeta image with the private key above and stores one copy of the public key in the signed vbmeta image. During AVB verification, the U-Boot validates the public key first, and then uses the public key to authenticate the signed vbmeta image.

8.6.2.2 Storing the AVB public key to a secure storage

The public key must be stored in the Trusty OS backed RPMB for Android if Trusty OS is enabled. Perform the following steps to set the public key.

Make your board enter fastboot mode and enter the following commands on the host side:

```
fastboot stage ${your-key-directory}/test_rsa4096_public.bin
fastboot oem set-public-key
```


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The public key `test_rsa4096_public.bin` should be extracted from the private key you have specified. But if you do not specify any private key, you should set the public key as `prebuilt testkey_public_rsa4096.bin`, which is extracted to form the default private key `testkey_rsa4096.pem`.

8.6.3 AVB boot key

The boot image is built as chained partition and the vbmeta struct in boot image is signed by a pair of asymmetric keys (AVB boot key. For more information about the chained partition, see https://android.googlesource.com/platform/external/avb/+/master/README.md.

By default, the Android platform uses the test AVB boot key to sign the boot image. It is located at:

```
${MY_ANDROID}/external/avb/test/data/testkey_rsa2048.pem
```

Custom keys should be used for production. See Section 8.6.2.1 to generate the custom private key. The AVB boot key and algorithm can be overridden by setting the following configurations:

```
BOARD_AVB_BOOT_ALGORITHM := <algorithm-type>
BOARD_AVB_BOOT_KEY_PATH := <key-path>
```

8.6.4 Key attestation

The keystore key attestation aims to provide a way to strongly determine if an asymmetric key pair is hardware-backed, what the properties of the key are, and what constraints are applied to its usage.

The Remote Key Provisioning (RKP) is now used to provision short-lived attestation keys to the devices. Contact Google about the tools and process to extract the Certificate Signing Request (CSR) and upload it to Google.

For devices that have not switched to use RKP, Google provides the attestation "keybox", which contains private keys (RSA and ECDSA) and the corresponding certificate chains to partners from the Android Partner Front End (APFE).

For more details, see the *i.MX Android Security User's Guide* (UG10158).

8.7 SCFW configuration

SCFW is a binary stored in `${MY_ANDROID}/vendor/nxp/fsl-proprietary/uboot-firmware`, built into bootloader.

To customize SCFW, download the SCFW porting kit on the i.MX Software and Development Tools page. For this release, click **Embedded Linux**, and then click the **RELEASES** tab. Find the Linux 6.18.20-2.0.0 release and download its corresponding SCFW Porting kit. Then decompress the file with the following commands:

```
tar -zxvf imx-scfw-porting-kit-1.18.0.tar.gz
cd packages
chmod a+x imx-scfw-porting-kit-1.18.0.bin
./imx-scfw-porting-kit-1.18.0.bin
cd imx-scfw-porting-kit-1.18.0/src
tar -zxvf scfw_export_mx8qm_b0.tar.gz       # for i.MX 8QuadMax MEK
tar -zxvf scfw_export_mx8qx_b0.tar.gz       # for i.MX 8QuadXPlus MEK
```

The SCFW porting kit contains prebuilt binaries, libraries, and configuration files. For the board configuration file, take i.MX 8QuadXPlus MEK as an example, it is `scfw_export_mx8qx_b0/platform/board/mx8qx_mek/board.c`. Based on this file, some changes are made for Android and the file is stored in `${MY_ANDROID}/vendor/nxp/fsl-proprietary/uboot-firmware/imx8q/board-imx8qxp.c`.

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You can copy `board.c in vendor/nxp/fsl-proprietary` to SCFW porting kit, modify it, and then build the SCFW.

The following are steps to build Android SCFW (taking i.MX 8QuadXPlus as example):

1. Download GCC tool from the arm Developer GNU-RM Downloads page. It is suggested to download the version of "6-2017-q2-update" as it is verified.
2. Unzip the GCC tool to `/opt/scfw_gcc`.
3. Export `TOOLS="/opt/scfw-gcc"`.
4. Copy the board configuration file from `${MY_ANDROID}/vendor/nxp/fsl-proprietary/uboot-firmware/imx8q/board-imx8qxp.c` to the porting kit.

```
cp ${MY_ANDROID}/vendor/nxp/fsl-proprietary/uboot-firmware/imx8q/board-
imx8qxp.c scfw_export_mx8qx_b0/platform/board/mx8qx_mek/board.c
```

5. Build SCFW.

```
cd scfw_export_mx8qx_b0     # enter the directory just uncompressed for i.MX
 8QuadXPlus MEK
make clean
make qx R=B0 B=mek
```

6. Copy the SCFW binary to the `uboot-firmware` folder.

```
cp build_mx8qx_b0/scfw_tcm.bin ${MY_ANDROID}/vendor/nxp/fsl-proprietary/
uboot-firmware/imx8q/mx8qx-scfw-tcm.bin
```

7. Build the bootloader.

```
cd ${MY_ANDROID}
./imx-make.sh bootloader -j4
```

Note:

To build SCFW for i.MX 8QuadMax MEK, use `qm` to replace `qx` in the steps above.

8.8 Miscellaneous configurations

8.8.1 Changing the boot command line in boot.img

After `boot.img` is used, the default kernel boot command line is inside this image. It packages together during the Android build.

You can change this by changing the value of `BOARD_KERNEL_CMDLINE` in the `BoardConfig.mk` file under `${MY_ANDROID}/device/nxp`.

Note:

- *For the i.MX 8M Mini EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8m/evk_8mm/BoardConfig.mk`.*
- *For the i.MX 8M Nano EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8m/evk_8mn/BoardConfig.mk`.*
- *For the i.MX 8M Plus EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8m/evk_8mp/BoardConfig.mk`.*
- *For the i.MX 8M Quad WEVK/EVK board, the source folder is `${MY_ANDROID}/device/nxp/imx8m/evk_8mq/BoardConfig.mk`.*

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- *For the i.MX 8ULP EVK board, the source folder is* `${MY_ANDROID}/device/nxp/imx8ulp/evk_8ulp/BoardConfig.mk`.
- *For the i.MX 8QuadMax/8QuadXPlus MEK board, the source folder is* `${MY_ANDROID}/device/nxp/imx8q/mek_8q/BoardConfig.mk`.
- *For the i.MX 95 EVK and FRDM-IMX95 board, the source folder is* `${MY_ANDROID}/device/nxp/imx9/evk_95/BoardConfig.mk`.
- *For the i.MX 952 EVK and FRDM-IMX952 board, the source folder is* `${MY_ANDROID}/device/nxp/imx9/evk_952/BoardConfig.mk`.
- *For the FRDM-IMX937 board, the source folder is* `${MY_ANDROID}/device/nxp/imx9/frdm_937/BoardConfig.mk`.

8.8.2 Modifying the super partition

The partition of super is used to hold logical partitions. Metadata describing the layout of logical partitions in super partition is at the beginning of the super partition. When the system boots up, the init program parses the metadata in super partition and creates logical partitions to mount.

With virtual A/B feature, the super partition can only have the size for one slot of logical partitions. Now the size of super partition is 4.0 GB. 10 MB reserved in this 4.0 GB for metadata. You can find the code as follows in `${MY_ANDROID}/device/nxp`:

```
BOARD_SUPER_PARTITION_SIZE := 4294967296
BOARD_NXP_DYNAMIC_PARTITIONS_SIZE := 4284481536
```

Refer to the following patch to change the super partition size to 4 GB:

```
diff --git a/common/partition/device-partitions-13GB-ab_super.bpt b/common/
partition/device-partitions-13GB-ab_super.bpt
index e6e7f1a..829821c 100644
--- a/common/partition/device-partitions-13GB-ab_super.bpt
+++ b/common/partition/device-partitions-13GB-ab_super.bpt
    @@ -39,7 +39,7 @@
             },
             {
                 "label": "super",
    -            "size": "4096 MiB",
    +            "size": "3584 MiB",
                 "guid": "auto",
                 "type_guid": "c1dedb9a-a0d3-42e4-b74d-0acf96833624"
             },
    diff --git a/imx8m/BoardConfigCommon.mk b/imx8m/BoardConfigCommon.mk
    index 20d65a3..ae42220 100644
    --- a/imx8m/BoardConfigCommon.mk
    +++ b/imx8m/BoardConfigCommon.mk
    @@ -135,8 +135,8 @@ ifeq ($(TARGET_USE_DYNAMIC_PARTITIONS),true)
           BOARD_NXP_DYNAMIC_PARTITIONS_SIZE := 4024434688
         endif
       else
    -    BOARD_SUPER_PARTITION_SIZE := 4294967296
    -    BOARD_NXP_DYNAMIC_PARTITIONS_SIZE := 4284481536
    +    BOARD_SUPER_PARTITION_SIZE := 3758096384
    +    BOARD_NXP_DYNAMIC_PARTITIONS_SIZE := 3747610624
       endif
       ifeq ($(IMX_NO_PRODUCT_PARTITION),true)
         BOARD_NXP_DYNAMIC_PARTITIONS_PARTITION_LIST := system system_ext vendor
    diff --git a/imx8q/BoardConfigCommon.mk b/imx8q/BoardConfigCommon.mk
    index 85d3561..c7352a2 100644
```


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```
--- a/imx8q/BoardConfigCommon.mk
+++ b/imx8q/BoardConfigCommon.mk
@@ -164,8 +164,8 @@ ifeq ($(TARGET_USE_DYNAMIC_PARTITIONS),true)
       BOARD_NXP_DYNAMIC_PARTITIONS_SIZE := 4024434688
     endif
   else
-    BOARD_SUPER_PARTITION_SIZE := 4294967296
-    BOARD_NXP_DYNAMIC_PARTITIONS_SIZE := 4284481536
+    BOARD_SUPER_PARTITION_SIZE := 3758096384
+    BOARD_NXP_DYNAMIC_PARTITIONS_SIZE := 3747610624
   endif
   ifeq ($(IMX_NO_PRODUCT_PARTITION),true)
     BOARD_NXP_DYNAMIC_PARTITIONS_PARTITION_LIST := system system_ext vendor
```

8.9 Notices before the debugging work

When doing the customization work, you may need to do some debugging work. The debugging work will be convenient and flexible if the read-only file systems are remounted as writable, so that the files in it can be replaced with the `adb push` command. It helps to avoid flashing the images again and saves time.

To remount the read-only file systems, perform the following steps:

1. Unlock the device.
2. Boot up the system to the Android platform.
3. Execute the following commands on the host. The second command takes seconds to finish.

```
$ adb root
$ adb disable-verity
```

4. Reboot the device, and execute the following command on the host:

```
$ adb root
$ adb remount
```

Then, the images can be pushed to the board with the `adb push` command. Before the further debugging work, be aware of the following notices:

- Do not erase the `userdata` partition after `adb disable-verity` is executed.
  With the dynamic partition feature enabled in i.MX Android images, and the size is not specified for `system`, `system_ext`, `vendor`, and `product` partitions when building the images. OverlayFS is used when remounting the read-only file systems. An upper directory that can be written in OverlayFS is needed in this condition. When the `adb push` command is executed, the files are pushed to the upper directory of OverlayFS, while the original read-only file systems are not modified.
  i.MX Android images use only one partition named `super` to store images in logical partitions, and `f2fs` file system is used for the userdata partition, which is mounted on `/data`. When executing the `adb disable-verity` command, an image is allocated under `/data/gsi/remount/scratch.img.0000`. Its size is the value of the property `fs_mgr.overlayfs.data_scratch_size_mb` if it is set. If not, the size is the less one between the `super` partition size and the `userdata` partition free space size. The layout information of this image is stored in `/metadata/gsi/remount/lpmetadata` in the format logical partition metadata. When rebooting the system, at the first stage of the `init` program, the information in `/metadata/gsi/remount/lpmetadata` is used to create a logical partition named `scratch`, and it is mounted on `/mnt/scratch`. This is used as the upper directory in OverlayFS used in remount. When the `adb push` command is executed to modify the originally read-only file systems, files are written to the `scratch` partition.
  At the first stage of the `init` program, the `userdata` partition is not mounted. The code judges whether the backing image of the `scratch` partition exists in the `userdata` partition by checking whether the `/`

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metadata/gsi/remount/lpmetadata file can be accessed. Therefore, if the userdata partition is erased, but the logical partition is still created, this could be catastrophic and may make the system crash.

- To modify the files from the console, execute remount on the console first.
  adb and sh are in different mount namespaces. adb remount does not change the mount status that sh sees.
- For MEK boards, if files need to be pushed to /vendor/etc, /vendor/lib64, and /vendor/firmware/tee, push them to another path.
  Images for i.MX 8Quad Max MEK and i.MX 8QuadXPlus MEK are built together with one target. Media codec configuration filenames and paths are hardcoded in the framework, while these two SoCs need different media codec configurations. It means that the media codec configuration files for the two boards with different content should have the same name and be accessed with the same path. Therefore, OverlayFS is used, and images for the two boards have different OverlayFS upper directories. The mount command can be found in ${MY_ANDROID}/device/nxp/imx8q/mek_8q/init.rc:

```
mount overlay overlay /vendor/etc ro lowerdir=/vendor/vendor_overlay_soc/
${ro.boot.soc_type}/vendor/etc:/vendor/etc,override_creds=off
mount overlay overlay /vendor/lib64 ro lowerdir=/system/lib64/
vendor_widevine_overlay_soc/${ro.boot.soc_type}/vendor/lib64:/vendor/
lib64,override_creds=off
mount overlay overlay /vendor/firmware/tee ro lowerdir=/vendor/
vendor_widevine_overlay_soc/${ro.boot.soc_type}/vendor/firmware/tee:/vendor/
firmware/tee,override_creds=off
```

  The value of ${ro.boot.soc_type} can be imx8qxp or imx8qm here.
  With the preceding command executed, access to files under /vendor/etc can access files both under /vendor/etc and /vendor/vendor_overlay_soc/${ro.boot.soc_type}/vendor/etc. The /vendor/vendor_overlay_soc/${ro.boot.soc_type}/vendor/etc:/vendor/etc directory is the upper directory in overlayfs and /vendor/etc is both the lower directory and mount point.
  After remount, the lower directory /vendor/etc is still read-only, and files can be pushed to other sub-paths under /vendor except /vendor/etc. To push a modified file, which should be accessed from /vendor/etc, push it to /vendor/vendor_overlay_soc/${ro.boot.soc_type}/vendor/etc, and then reboot the system to make it take effect.
  For example, if you modified the file cdnhdmi_config.json, a file should be under /vendor/etc/configs/audio/. Execute the following commands on the console:

```
su
umask 000
cd /vendor/vendor_overlay_soc/imx8qm/vendor/etc/
mkdir -p configs/audio/
```

  Then, execute the following commands on the host:

```
sudo adb push cdnhdmi_config.json /vendor/vendor_overlay_soc/imx8qm/vendor/etc/
```

  At last, reboot the device to make this change take effect.
  There are two limitations here:
  – To delete a file under /vendor/etc/, you can only rebuild the image and flash the vendor image again.
  – The OverlayFS is mounted with a command in an init .rc file. The init .rc files are all parsed by the init program before the OverlayFS is mounted. Therefore, to modify init .rc files under /vendor/etc, you can only rebuild the image and flash the vendor image again.
- For i.MX 8M Plus EVK boards, if files need to be pushed to /vendor/etc/configs/isp, push them to another path.
  Similar to the condition of images for MEK boards, the images for i.MX 8M Plus EVK board support different Cameras, which require different configurations. The different configuration files have the same name, and

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need to be accessed from the same directory of `/vendor/etc/configs/isp`, so OverlayFS is used and mounted on this directory for some camera usages, and this directory is still read-only after remount.
The mount commands can be found in `${MY_ANDROID}/device/nxp/imx8m/evk_8mp/init.rc`.

```
# default is for dual os08a20
on property:ro.boot.camera.layout=""
    mount overlay overlay /vendor/etc/configs/isp ro lowerdir=/vendor/
vendor_overlay_sensor/os08a20/vendor/etc/configs/isp:/vendor/etc/configs/
isp,override_creds=off

# androidboot.camera.layout=basler-ov5640
on property:ro.boot.camera.layout=basler-ov5640
    setprop ro.media.xml_variant.profiles _8mp-ispsensor-ov5640
    mount overlay overlay /vendor/etc/configs/isp ro lowerdir=/vendor/
vendor_overlay_sensor/basler/vendor/etc/configs/isp:/vendor/etc/configs/
isp,override_creds=off

# androidboot.camera.layout=only-ov5640
on property:ro.boot.camera.layout=only-ov5640
    setprop ro.media.xml_variant.profiles _8mp-ov5640

on property:ro.boot.camera.layout=os08a20-ov5640
    setprop ro.media.xml_variant.profiles _8mp-ispsensor-ov5640
    mount overlay overlay /vendor/etc/configs/isp ro lowerdir=/vendor/
vendor_overlay_sensor/os08a20/vendor/etc/configs/isp:/vendor/etc/configs/
isp,override_creds=off

on property:ro.boot.camera.layout=dual-basler
    mount overlay overlay /vendor/etc/configs/isp ro lowerdir=/vendor/
vendor_overlay_sensor/basler/vendor/etc/configs/isp:/vendor/etc/configs/
isp,override_creds=off
```

Files need to be pushed to the following directories based on the camera you are debugging with:

- `/vendor/vendor_overlay_sensor/basler/vendor/etc/configs/isp`
- `/vendor/vendor_overlay_sensor/os08a20/vendor/etc/configs/isp`

The limitations described in the preceding part for MEK images also exist in the images for the i.MX 8M Plus EVK board:

- To delete a file under `/vendor/etc/configs/isp`, you can only rebuild the image and flash the vendor image again.
- The OverlayFS is mounted with a command in an `init .rc` file. The `init .rc` files are all parsed by `init` before the OverlayFS is mounted. Therefore, to modify `init .rc` files under `/vendor/etc/configs/isp`, you can only rebuild the image and flash the vendor image again.

If only one camera usage is needed, the OverlayFS mount commands can be removed from the `init.rc` file and put the corresponding configuration files directly under `/vendor/etc/configs/isp`.

8.10 CTS on USB camera

See https://source.android.com/docs/compatibility/cts/setup#cameras. If the DUT supports external cameras, such as USB webcams, plug in an external camera when running the CTS. Otherwise, the CTS tests fail. Due to the patch Camera CTS: Verify external camera by checking all connected cameras in the CTS, if the board supports USB camera (`/vendor/etc/permissions/android.hardware.camera.external.xml` exists), the USB camera must be connected when running the CTS, or most camera related tests will fail.

NXP uses the build parameter `PERMISSION_EXTCAM` to decide whether to copy `android.hardware.camera.external.xml` or not.

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Taking i.MX 8M Mini as an example, see `ANDROID_ROOT/deivce/nxp/imx8m/evk_8mm/evk_8mm.mk`:

```
    PERMISSION_EXTCAM ?= true
    ifeq ($(PERMISSION_EXTCAM),true)
    PRODUCT_COPY_FILES += \
        frameworks/native/data/etc/android.hardware.camera.external.xml:vendor/
etc/permissions/android.hardware.camera.external.xml
    endif
```

Currently, for a release image, `PERMISSION_EXTCAM` is `false` on the i.MX 8QuadMax, 8QuadXPlus, 8M Mini, and 8M Nano, `true` on the i.MX 8M Plus, 8M Quad, 8ULP, i.MX 95, i.MX 952, and i.MX 937 by default. Therefore, on i.MX 8M Plus, 8M Quad, 8ULP, i.MX 95, i.MX 952, and i.MX 937, connect the USB camera when running CTS. On i.MX 8QuadMax, 8QuadXPlus, 8M Mini, and 8M Nano, although there is no `vendor/etc/permissions/android.hardware.camera.external.xml`, the USB camera still works properly with camera APKs.

9 Generic Kernel Image (GKI) development

9.1 GKI introduction

The Generic Kernel Image (GKI) project addresses kernel fragmentation by unifying the core kernel and moving SoC and board support out of the core kernel into loadable modules. The GKI kernel presents a stable Kernel Module Interface (KMI) for kernel modules, so modules and kernel can be updated independently.

Devices that launch from the Android 14 (2023) platform release using kernel versions v5.15 or higher are required to ship with the GKI kernel.

The following boards have enabled GKI:

- i.MX 8M Mini Board
- i.MX 8M Nano Board
- i.MX 8M Plus EVK Board
- i.MX 8M Quad WEVK/EVK Board
- i.MX 8ULP EVK Board
- i.MX 8QuadMax MEK Board
- i.MX 8QuadXPlus MEK Board
- i.MX 95 EVK Board
- i.MX 952 EVK Board
- FRDM-IMX937 Board

All platforms use the Kleaf (Bazel) build system. Each platform has its own `.bzl` configuration file (for example, `imx8mp.bzl`, `imx943.bzl`) under the `vendor/nxp-opensource/kernel_imx` repository.

9.2 Changes after GKI enabled

There are some changes after GKI is enabled.

- `boot.img`
  After GKI is enabled, the `boot.img` is a composite image that includes the AOSP generic kernel image and boot parameters.
  It is built from one prebuilt `boot.img`, stored in the android source code `${MY_ANDROID}/vendor/nxp-opensource/imx-gki/boot.img`. This `boot.img` is certified and released from AOSP, and then signed with the AVB key to generate final `boot.img`.

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By default, the UUU and fastboot script flash this image.
To build `boot.img`, run `./imx-make.sh` or `make bootimage`.

- `system_dlkm.img`
  `system_dlkm.img` is signed by Google using the kernel build-time key pair and are compatible only with the GKI they are built with. There is no ABI stability between `boot.img` and `system_dlkm.img`. For modules to load correctly during runtime, `boot.img` and `system_dlkm.img` must be built and updated together.
- `boot-imx.img`
  `boot-imx.img` is built from the i.MX kernel tree for debugging purposes.
  With Bazel/Kleaf build, `boot-imx.img` is built by Bazel and copied to `${OUT}/boot-imx.img` automatically.
- `system_dlkm-imx.img`
  `system_dlkm-imx.img` is built from the i.MX kernel tree. It must be updated together with `boot-imx.img`. The modules in `system_dlkm-imx.img` are only compatible with the kernel in `boot-imx.img` from the same build.
  With Bazel/Kleaf build, `system_dlkm-imx.img` is built by Bazel and copied to `${OUT}/system_dlkm-imx.img` automatically.
- Kernel `defconfig`
  In GKI mixed build, there are two `.config` files:
  – GKI base kernel: uses `gki_defconfig` to compile the kernel Image and `system_dlkm` modules.
  – Vendor kernel: uses `gki_defconfig` + board-specific fragment (such as `imx8mm_gki.fragment`) to compile vendor modules and DTBs.

  Both of them use the same kernel source but different configurations. After building, these `.config` files are copied to `${OUT}/obj/BAZEL_PREBUILT/debug/` for inspection:
  – `gki.defconfig`: GKI base kernel `.config`
  – `<soc>.defconfig`: Vendor kernel `.config` (such as `imx8mm.defconfig`)
- Driver modules
  As GKI requires, all vendor drivers need to be built as modules. Their configurations are set as `m` in the board-specific fragment file. Modules are defined in each platform's `.bzl` file (such as `imx8mm.bzl`) under `vendor/nxp-opensource/kernel_imx`:
  – `_<SOC>_VENDOR_RAMDISK_MODULES`: Early boot modules. Bazel builds these into a ramdisk (`ramdisk.lz4`), which is then used by Android `make vendorbootimage` to generate `vendor_boot.img`.
  – `_<SOC>_VENDOR_DLKM_MODULES`: Deferred modules, packaged into `vendor_dlkm.img` by Bazel.
  – `_<SOC>_IMPLICIT_MODULES`: Modules produced by `Kconfig` dependencies.
  Note: *Kleaf reports an error if a built module is not listed in either `module_outs` or `module_implicit_outs`.*
- ***Note:*** *Due to SoC errata TKT340553 in i.MX 8QuadMax, it has not fully enabled GKI. The `boot_8q.img` and `system_dlkm_8q` are built locally for both i.MX 8QuadMax and i.MX 8QuadXPlus.*

9.3 How to add new drivers

Perform the following steps to add new drivers:

1. Set the driver configuration to `m` in the configuration fragment file of the board under the `vendor/nxp-opensource/kernel_imx` repository.
   The following takes the HDMIRX driver on the i.MX 8Quad as an example. For other SoCs, use the corresponding `$SOC_gki.fragment` file.

```
diff --git a/arch/arm64/configs/imx8q_gki.fragment b/arch/arm64/configs/
imx8q_gki.fragment
index 51ce20e5920d..e54f96cc5469 100644
--- a/arch/arm64/configs/imx8q_gki.fragment
```


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```
+++ b/arch/arm64/configs/imx8q_gki.fragment
@@ -148,3 +148,4 @@ CONFIG_TRUSTY_CRASH_IS_PANIC=y
CONFIG_SOC_IMX8M=m
CONFIG_I2C_MUX=m
CONFIG_I2C_MUX_GPIO=m
+CONFIG_MHDP_HDMIRX=m
```

2. Add the driver `.ko` path to the platform's `.bzl` file under `vendor/nxp-opensource/kernel_imx`:
   Note: *If other driver modules depend on them, put them before others.*
   a. Determine the module type:
   Required for early boot: add to `_<SOC>_VENDOR_RAMDISK_MODULES`.
   Deferred loading: add to `_<SOC>_VENDOR_DLKM_MODULES`.
   Take i.MX 8Quad as an example (edit `imx8q.bzl`):

```
_IMX8Q_VENDOR_DLKM_MODULES = [
    # ... existing modules ...
    "drivers/media/platform/nxp/hdmirx/cdns_mhdp_hdmirx.ko",
]
```

3. Build the driver with Bazel/Kleaf:

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch {TARGET_PRODUCT}-nxp_stable-userdebug
$ ./imx-make.sh vendor_dlkmimage -j8       # If added to VENDOR_DLKM
$ ./imx-make.sh vendorbootimage -j8        # If added to VENDOR_RAMDISK
```

4. Build and flash images:

```
$ ./imx-make.sh -j8 2>&1 | tee build-log.txt
```

After all the images are flashed, check whether the board can boot and check whether the new driver module is loaded with the `lsmod` command. If yes, skip the rest steps in this section. If not, you may encounter symbol errors as follows:

```
# dmesg | grep symbol
"cdns_mhdp_hdmirx: Protected symbol: XXX (err -13)"
"cdns_mhdp_hdmirx: Unknown symbol XXX (err -2)"
```

If the driver module is put into `_<SOC>_VENDOR_RAMDISK_MODULES` instead of `_<SOC>_VENDOR_DLKM_MODULES`, your system may get stuck at "Starting kernel..." if any symbols are missing. Follow the next section to fix it by adding the missing symbols to `gki/aarch64/abi.stg`.
For debugging purposes and quick verification, flash `boot-imx.img` and `system_dlkm-imx.img` (built from the i.MX kernel tree) instead of the prebuilt GKI `boot.img` and `system_dlkm.img`. This ensures the kernel and modules come from the same build, avoiding "Unknown symbol" or "Protected symbol" errors.
The two partitions require different fastboot modes:

- `boot`: flash in bootloader mode (`adb` reboot bootloader).

```
$ fastboot flash boot ${OUT}/boot-imx.img
```

- `system_dlkm`: a dynamic partition, flash in fastbootd mode (`adb` reboot fastboot).

```
$ fastboot flash system_dlkm ${OUT}/system_dlkm-imx.img
```


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If you still encounter "Unknown symbol" errors, check if the symbols are exported by `EXPORT_SYMBOL` or by modules that are not loaded into the system. If so, add these modules to the `.bzl` file, regenerate the patch and rebuild the images as before.

9.4 How to build GKI locally to support new drivers

This section aims to address the symbol errors that were encountered in the previous section.

Make sure that you followed the previous section, adding all the modules to the platform's `.bzl` file, and then generating a patch.

1. Use the Bazel workspace
   If you have already run `setup_android_kernel_bazel.sh` (see Section 3.2), the Bazel workspace is already set up at `$BAZEL_WORKSPACE_DIR`. The symbolic links (`kernel_imx`, `nxp-mwifiex`, and `verisilicon_sw_isp_vvcam`) are already created.

   ```
   $ cd $BAZEL_WORKSPACE_DIR
   ```

   If the workspace is not set up yet, follow the setup steps in Section 3.2 first.
2. Update the i.MX symbol list.
   Note: *If you have any other patches on the i.MX kernel, apply them all in this step.*

   ```
   $ tools/bazel run //kernel_imx:imx8q_abi_update_symbol_list --jobs=32
   $ sed -i '/TKT340553_SW_WORKAROUND/d;/from_kuid_munged/d;/
   devm_otg_ulpi_create/d;/ulpi_viewport_access_ops/d' kernel_imx/gki/aarch64/
   symbols/imx
   ```

   Note: *Replace `imx8q` with the target platform name (for example, `imx8mp`, `imx952`). Each platform has its own `_abi_update_symbol_list` target. To update symbols for all platforms:*

   ```
   $ for soc in imx8mp imx8mm imx8mn imx8mq imx8q imx8ulp imx95 imx952; do
   $     tools/bazel run //kernel_imx:${soc}_abi_update_symbol_list --jobs=32
   $ done
   ```
3. Update the AOSP symbol list.

   ```
   $ cd common
   $ git checkout aosp/android17-6.18-2026-09
   $ cd ..
   $ cp kernel_imx/gki/aarch64/symbols/imx common/gki/aarch64/symbols/imx
   $ tools/bazel run //common:kernel_aarch64_abi_update
   ```

   You may encounter the following build error, which indicates that `file_open_root` is not allowed for the vendor use under GKI. Remove these symbols from `gki/aarch64/symbols/imx` manually. Then, run `tools/bazel run //common:kernel_aarch64_abi_update` again.

   ```
   Symbols missing from the ksymtab:
     file_open_root
   Target //common:kernel_aarch64_abi_update failed to build
   ```

   If the following log is displayed after the command is completed, it works. Proceed to the next steps.

   ```
   ERROR: ABI DIFFERENCES HAVE BEEN DETECTED!
   ERROR: Report summary:
   1 function symbol(s) added
     'int phylink_init_eee(struct phylink*, bool)'
   ```


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4. (Optional) Enable the early console.
   This step is optional and is only used for debugging, particularly when the system gets stuck at "Starting kernel...".
   Apply the following patch and resolve any conflicts that arise.

```
$ git am -3 ${MY_ANDROID}/vendor/nxp-opensource/imx-gki/debug_patches/0001-
MA-19811-tty-imx_earlycon-Support-lpuart-earlycon.patch
```

5. Apply the local patches (only for i.MX 8QuadXPlus and 8QuadMax MEK boards).
   To address TKT340553 Errata and support for multiple states domains, i.MX 8QuadXPlus and 8QuadMax need to apply out-of-tree patches to function well with the GKI image.

```
$ git am -3 ${MY_ANDROID}/vendor/nxp-opensource/imx-gki/boot_8q_patches/
*.patch
```

6. Build GKI `boot.img` and `system_dlkm.img` locally.

```
$ cd $BAZEL_WORKSPACE_DIR
$ tools/bazel run //common:kernel_aarch64_dist
$ cp out/kernel_aarch64/dist/boot.img ${MY_ANDROID}/vendor/nxp-opensource/
imx-gki/boot.img
$ cp out/kernel_aarch64/dist/system_dlkm.erofs.img ${MY_ANDROID}/vendor/nxp-
opensource/imx-gki/system_dlkm.img
$ cd ${MY_ANDROID}/vendor/nxp-opensource/imx-gki/
$ git add boot.img system_dlkm.img
$ git commit -s -m "Update gki boot.img and system_dlkm.img"
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch {TARGET_PRODUCT}-nxp_stable-userdebug
$ ./imx-make.sh -j8 2>&1 | tee build-log.txt
```

   Now, you have built GKI locally to support the new driver. If your device does not need to pass Google certification, these steps are sufficient, and you can skip the following section. If not, continue with the next section.
   Note: *If you encounter the log "disagrees about version of symbol" during system boot, it indicates that the i.MX kernel changes have affected the GKI common structures. After running* `git checkout aosp/android17-6.18-2026-09`*, apply the i.MX kernel changes. Then, update the AOSP symbol list and rebuild both GKI* `boot.img` *and* `system_dlkm.img` *locally.*

9.5 How to make AOSP-released GKI support new drivers

This section aims to upstream a kernel patch to make AOSP-released GKI support the new driver.

Make sure that you have followed the previous sections to generate the new i.MX symbol list: `kernel_imx/gki/aarch64/symbols/imx`.

1. Generate a patch to declare new symbols.

```
$ cd $BAZEL_WORKSPACE_DIR
$ cp kernel_imx/gki/aarch64/symbols/imx common/gki/aarch64/symbols/imx
$ tools/bazel run //common:kernel_aarch64_abi_update
$ cd common
$ git add gki/aarch64/symbols/imx gki/aarch64/abi.stg
$ git commit -m "ANDROID: GKI: Add new symbols"
$ git format-patch -1
```

2. Submit the patch to AOSP.

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See this guide: How do I submit patches to Android Common Kernels.
One example patch is: ANDROID: GKI: Add symbol to symbol list for imx.
In addition, see this guide about GKI release processes: GKI release process.
In short, send the patch to the `aosp/android17-6.18` development branch for review. After it is accepted, follow the respin process to make the patch into a quarterly release branch: `aosp/android17-6.18-2026-09`.

3. Use the newly released GKI image.
   Find the latest release GKI here: Generic Kernel Image (GKI) release builds.
   Download `boot-6.18.img` from the **Certified GKI** column in the **Release build** table. Unzip the downloaded package to get `boot-6.18.img`.
   Download the matched `system_dlkm.erofs.img` from the **Kernel artifacts** column in the **Release build** table.

```
$ cp ${Downloads}/boot-6.18.img ${MY_ANDROID}/vendor/nxp-opensource/imx-gki/
boot.img
$ cp ${Downloads}/system_dlkm.erofs.img ${MY_ANDROID}/vendor/nxp-opensource/
imx-gki/system_dlkm.img
$ cd ${MY_ANDROID}/vendor/nxp-opensource/imx-gki/
$ git add boot.img system_dlkm.img
$ git commit -s -m "Update gki boot.img and system_dlkm.img"
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch {TARGET_PRODUCT}-nxp_stable-userdebug
$ ./imx-make.sh -j8 2>&1 | tee build-log.txt
```

Note: *`boot.img` and `system_dlkm.erofs.img` must be downloaded from the exact same build. Otherwise, the modules from `system_dlkm.img` may fail to load with "exports protected symbol" warnings.*

10 imx-chip-tool application

Matter (previously known as Project CHIP) is a universal IPv6-based application-layer communication protocol for smart home devices. Matter supports UDP and TCP at the transport layer, and supports Ethernet, Wi-Fi, Thread, Bluetooth Low Energy (BLE) at the link layer. Depending on the networking technologies supported by a device, discovery and commissioning are possible using BLE, Wi-Fi technologies, or over IP, if a device is already on an IP network. Devices that use Thread networking technology must also support BLE for the purposes of discovery and commissioning.

The `imx-chip-tool` application is a pre-installed apk on the i.MX 8M Nano. It is a Matter Controller implementation that allows users to discover and commission a Matter device on the network and communicate with it using Matter messages. This application currently supports commissioning with three types of devices:

- On Network Device
  This method is used to discover and communicate with Matter devices on the same LAN as the Matter Controller. The Android device discovers and communicates with a Matter device over IP.
- Wi-Fi Device
  This method is used to discover and communicate with Matter devices that support Wi-Fi. The Android device connected to a Wi-Fi AP that supports IPv6, discovers a Matter device through BLE, joins the Matter device to the Wi-Fi network, and then communicates with it over the Wi-Fi network.
- Thread Device
  This method is used to discover and communicate with Matter devices that support Thread. The Android device discovers a Thread device through BLE, joins the Thread device to the Matter network through the Open Thread Board Router (OTBR) (The Android device and the OTBR are on the same Wi-Fi network, and the OTBR and the Thread device are on the same Thread network. Together, they form a Matter network), and then communicates with the Thread device over IP.

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11 Running Android OS on Xen on i.MX 95 19x19 EVK

This section includes two parts:

- Demonstration of running Android Trout image in Xen with the prebuilt images.
- The description of how to build the Android Trout image used in Xen. This section describes how to customize the images.

11.1 Running with the prebuilt images

In this demonstration, there are two operating systems:

- Yocto running in Xen Dom0
- Android Trout running in Xen DomU

11.1.1 Downloading and flashing the Yocto image

Download the Yocto LF6.18.37_2.1.0 release from the following URL for i.MX 95 19x19 EVK: https://www.nxp.com/design/design-center/software/embedded-software/i-mx-software/embedded-linux-for-i-mx-applications-processors:IMXLINUX.

Switch to serial download mode, and flash the image with the `uuu` command as follows. The default `uuu` script in the release zip package uses eMMC as the target device.

```
sudo uuu LF_v6.18.20-2.0.0_images_IMX95.zip/uuu.auto-imx95-19x19-lpddr5-evk
```

Switch to a proper boot mode to boot up the Yocto image. To have the Xen support in use, execute the following U-Boot commands to run the image:

```
U-Boot=> setenv xenlinux_addr 0x9c000000
U-Boot=> setenv dom0fdt_file imx95-19x19-evk-adv7535-ap1302.dtb
U-Boot=> setenv xenhyper_bootargs "console=dtuart dom0_mem=8192M
 dom0_max_vcpus=2 pci-passthrough=true"
U-Boot=> run xenmmcboot
```

With the last command above, the Yocto image is started with Xen support. Log in with the account `root`.

11.1.2 Installing the Android Trout image

The `android-17.0.0_1.0.0_image_trout.tar.gz` in the Android release package contains the Android Trout image.

Uncompress the package. There are two files that need to be stored in the Yocto environment:

- `u-boot.bin`: A U-Boot image file.
- `disk.img`: A composite disk image file containing the kernel and the Android filesystem. Actually, it is `disk.img.zst` in the compression package. Uncompress it again to get this `disk.img`.

A new partition larger than 15 GB needs to be created in Yocto with the `fdisk` command. An example of creating the partition on eMMC is as follows:

```
    root@cn-szh02-ns-pr002:~# fdisk /dev/mmcblk0
            # start the fdisk command

    Welcome to fdisk (util-linux 2.40.4).
    Changes will remain in memory only, until you decide to write them.
    Be careful before using the write command.
```


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```
   This disk is currently in use - repartitioning is probably a bad idea.
   It's recommended to umount all file systems, and swapoff all swap
   partitions on this disk.


   Command (m for help): p
           # print the partition table

   Disk /dev/mmcblk0: 59.28 GiB, 63652757504 bytes, 124321792 sectors
   Units: sectors of 1 * 512 = 512 bytes
   Sector size (logical/physical): 512 bytes / 512 bytes
   I/O size (minimum/optimal): 512 bytes / 512 bytes
   Disklabel type: dos
   Disk identifier: 0x076c4a2a

   Device         Boot  Start      End  Sectors  Size Id Type
   /dev/mmcblk0p1 *     16384   540671   524288  256M  c W95 FAT32 (LBA)
   /dev/mmcblk0p2      540672 21103361 20562690  9.8G 83 Linux

   Command (m for help): n
           # add a new partition
   Partition type
   p   primary (2 primary, 0 extended, 2 free)
   e   extended (container for logical partitions)
   Select (default p): p
           # select the primary type
   Partition number (3,4, default 3):
           # use the default partition number
   First sector (2048-124321791, default 2048): 21103362
           # use the sector after mmcblk0p2 as the first sector
   Last sector, +/-sectors or +/-size{K,M,G,T,P} (21103362-124321791, default
124321791):  # use the default last sector value

   Created a new partition 3 of type 'Linux' and of size 49.2 GiB.
   Partition #3 contains a ext4 signature.

   Do you want to remove the signature? [Y]es/[N]o: Y
           # remove the signature as the new partition was formatted before

   The signature will be removed by a write command.

   Command (m for help): w
           # write table to disk and exit
   The partition table has been altered.
   Syncing disks.
```

Format the new partition as Ext4:

```
root@cn-szh02-ns-pr002:~# mkfs.ext4 /dev/mmcblk0p3
```

Mount the partition to a newly created directory:

```
$ mkdir /root/image
$ mount /dev/mmcblk0p3 /root/image
```

Copy the Trout image files to Yocto.

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Connect an Ethernet cable to the i.MX 95 19X19 EVK. A network connection of the Yocto helps use the `scp` command as follows to copy the files from the host to the Yocto. The `<ip_addr>` in the following commands is the IP address of the i.MX 95 19X19 EVK.

```
scp disk.img root@<ip_addr>:/root/image/
scp u-boot.bin root@<ip_addr>:/root/
```

11.1.3 Configuration for launching the Guest OS

Create the configuration file `/root/imx95_trout.conf` in the Yocto with the following content:

```
    kernel = "/root/u-boot.bin"
    disk = [ '/root/image/disk.img,,xvda,backendtype=qdisk,specification=virtio']
    cmdline = "console=hvc0 rw"
    vif = [ 'model=virtio-net,type=ioemu,bridge=xenbr0' ]
    name = "DomU"
    memory = "4096"
    vcpus = 6
    cpus = ['0', '1', '2', '3', '4', '5']
    virtio = [
    'backend=0,type=virtio,device,transport=mmio,grant_usage=false',

 'backend=0,type=virtio,device,transport=pci,bdf=00:01.0,backend_type=qemu,grant_usage=0',

 'backend=0,type=virtio,device,transport=pci,bdf=00:02.0,backend_type=qemu,grant_usage=0',

 'backend=0,type=virtio,device,transport=pci,bdf=00:03.0,backend_type=qemu,grant_usage=0',
    ]
    device_model_args = [
    '-device', 'virtio-sound-
pci,iommu_platform=true,audiodev=pipewire,bus=pcie.0,addr=3.0',
    '-audiodev', 'pipewire,id=pipewire',
    '-global', 'virtio-mmio.force-legacy=false',
    '-display', 'sdl,gl=es,full-screen=on',
    '-device', 'virtio-gpu-
gl,iommu_platform=true,hostmem=1G,bus=pcie.0,addr=1.0,blob=true',
    '-device', 'vhost-vsock-pci,iommu_platform=true,id=vhost-vsock-
pci0,bus=pcie.0,addr=2.0,guest-cid=3'
    ]
    device_model_override="/usr/bin/qemu-system-aarch64"
```

The file can be directly created in the Yocto with the `vi` command, or created on the host and copied to the Yocto with the `scp` command.

Execute the following commands in Yocto to configure the network. Make sure `eth0` is connected to the network.

```
    ip addr flush dev eth0
    # Create bridge
    brctl addbr xenbr0
    echo 0 > /sys/class/net/xenbr0/bridge/default_pvid
    brctl addif xenbr0 eth0
    # Set bridge and physical interface up
    ip link set dev xenbr0 up
    ip link set dev eth0 up
    ifconfig
    ifconfig -a
    ip address add 192.168.0.120/24 dev xenbr0
```


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Execute the following commands to configure the Xen in Yocto:

```
export SDL_VIDEODRIVER=wayland
systemctl --user --now enable pipewire wireplumber
```

11.1.4 Launching the Android Trout as Xen guest OS

Perform the following steps to launch the Android Trout as Xen guest OS:

1. Launch the Xen guest OS with the following command:

```
xl create /root/imx95_trout.conf
```

2. The following command can be used to check the states of OSes running in different domains:

```
xl list
```

3. Its output is as follows. Pay attention to the ID of DomU, which is used later when assigning a USB device to DomU.

```
Name              ID   Mem   VCPUs     State    Time(s)
Domain-0          0   8192     2       r-----   772.9
DomU              1   4096     6       -b----   1497.0
```

4. To access the DomU console, execute the following command:

```
xl console DomU
```

5. To return to the Yocto console, press the key combination **Ctrl+]**.

11.1.5 Enabling ADB over network in Android Trout

Access the DomU console with the command described previously. Execute the following command on the DomU console:

```
ifconfig               # get the ip address with this command

setprop service.adb.tcp.port 5555
stop adbd
start adbd
```

Then, on the host machine, execute the following command to connect to Trout:

```
adb connect <ip_addr>:5555
```

Ensure that the host machine and Trout are in the same subnet. The `<ip_addr>` is the IP address retrieved with the `ifconfig` command executed on the DomU console. After the host ADB is connected to the Trout, the `adb` command can be executed on Trout.

11.2 Building the Android Trout image used in Xen

To build the Android Trout image used in Xen, first, prepare the host machine environment.

Install necessary packages with the following commands:

```
sudo apt-get install -y build-essential libparted-dev python3.10-dev pkg-config
```


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```
pip install pyparted
```

11.2.1 Synchronizing the code and building the bootloader and kernel

Perform the following steps to synchronize the code and build the bootloader and kernel:

1. Create a directory to hold the bootloader project, use the shell environment variable `${MY_XEN_BOOTLOADER}` to point to this directory. Synchronize the bootloader project with the following commands:

```
cd ${MY_XEN_BOOTLOADER}

repo init -u https://github.com/nxp-imx/imx-manifest -b imx_xen_guest -m
 xen_guest_bootloader_imx_2024.xml
repo sync -c
```

2. Apply the patches under `${MY_ANDROID}/device/google/trout/patches/uboot/` to the U-Boot repository just synchronized with the following commands:

```
cp ${MY_ANDROID}/device/google/trout/patches/uboot/*.patch
 ${MY_XEN_BOOTLOADER}/u-boot/
cd ${MY_XEN_BOOTLOADER}/u-boot/
git am -3 0001-xen-xenguest_arm64-map-all-VIRTIO-MMIO-region.patch
git am -3 0002-MA-22692-necessary-config-change-for-enable-trout-on.patch
cd ${MY_XEN_BOOTLOADER}/
tools/bazel run //u-boot:xen_aarch64_dist  #build the u-boot binary
```

3. With the preceding commands executed successfully, copy the generated `u-boot.bin` file to a directory in the i.MX Android project:

```
cp ${MY_XEN_BOOTLOADER}/u-boot/out/u-boot/dist/u-boot.bin ${MY_ANDROID}/
vendor/nxp-opensource/imx_virt_prebuilts/uboot/prebuilts/
```

4. If the target directory does not exist, create it manually first.
   Create a directory to hold the Android Trout kernel project. Use the shell environment variable `${MY_XEN_KERNEL}` to point to this directory. Synchronize the code, apply related patches, and build the kernel with the following commands:

```
cd ${MY_XEN_KERNEL}/
repo init -u https://github.com/nxp-imx/imx-manifest -b imx_xen_guest -m
 xen_guest_kernel_imx_2024.xml
repo sync -c

cp ${MY_ANDROID}/device/google/trout/patches/kernel/0001-MA-22692-Add-
necessary-config-for-xen-booting-Androi.patch ${MY_XEN_KERNEL}/common/
cp ${MY_ANDROID}/device/google/trout/patches/kernel/0001-don-t-generate-the-
AVB-images.patch ${MY_XEN_KERNEL}/common-modules/virtual-device/
cd ${MY_XEN_KERNEL}/common/
git am -3 0001-MA-22692-Add-necessary-config-for-xen-booting-Androi.patch
cd ${MY_XEN_KERNEL}/common-modules/virtual-device/
git am -3 0001-don-t-generate-the-AVB-images.patch

cd ${MY_XEN_KERNEL}/
tools/bazel run //common-modules/virtual-device:virtual_device_aarch64_dist
```


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5. With the preceding commands executed successfully, copy the generated directory to a directory in the i.MX Android project:

```
mkdir -p ${MY_ANDROID}/vendor/nxp-opensource/imx_virt_prebuilts/kernel/
prebuilts/
cp -r out/virtual_device_aarch64/dist ${MY_ANDROID}/vendor/nxp-opensource/
imx_virt_prebuilts/kernel/prebuilts/
```

11.2.2 Building the Android Trout image

Execute the following commands in the i.MX Android project:

```
cd ${MY_ANDROID}

source build/envsetup.sh
lunch aosp_trout_arm64-trunk_staging-userdebug
m -j16
```

The generated `u-boot.bin` and `disk.img` can be found in the `${OUT}` directory. They are the Android Trout image files, which can be used to start Trout in Xen DomU.

12 Running CHRE on i.MX 95

Context Hub Runtime Environment (CHRE) provides a common platform for running applications on a low-power processor, with a simple, standardized, embedded-friendly API. CHRE makes it easy for device OEMs and their trusted partners to offload processing from the AP, to save battery and improve various areas of the user experience.

The CHRE feature includes four parts:

- i.MX context hub HAL: It is the channel connecting `contexthubService` and CHRE RPMsg driver.
- CHRE RPMsg driver: It is a Linux driver, which communicates with a low-power processor.
- CHRE framework: Mainly includes the ContextHub framework and some static NanoApps.
- MCU CHRE DEMO: It runs on a low-power processor. The CHRE framework is statically linked into it.

This section provides an example for the i.MX 95 board to build an Android image containing the CHRE feature.

12.1 Building the CHRE image

The CHRE build system is based on Make, and uses a set of Makefiles that allow building the CHRE framework for a variety of hardware and software architectures and variants (for example, different combinations of CPU and OS/underlying system). It is also flexible to different build toolchains (though LLVM/Clang or GCC are recommended), by abstracting out key operations to a few Make or environment variables.

12.1.1 Building the CHRE framework image

The Context Hub Runtime Environment (CHRE) framework for i.MX is cross-compiled for the Arm Cortex-M7 core with the Arm GNU BareMetal toolchain. Install the required host packages before building as follows:

```
$ sudo apt update
$ sudo apt install -y make build-essential cmake xxd protobuf-compiler
```

The Arm GNU BareMetal toolchain path is provided to the CHRE build system by the `CORTEXM_TOOLS_PREFIX` variable, whose default value is `/opt/arm-gnu-toolchain-12.3.rel1-`

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x86_64-arm-none-eabi. If the toolchain is installed at this default location, nothing has to be configured. Otherwise, set CORTEXM_TOOLS_PREFIX to an environment variable according to the actual installation directory:

```
$ export CORTEXM_TOOLS_PREFIX=/path/to/arm-gnu-toolchain
```

The value taken from the environment or from the make command line always overrides the default one defined in ${MY_ANDROID}/system/chre/Makefile and ${MY_ANDROID}/system/chre/build/nanoapp/app.mk.

The Android build environment should be set up as described in Section 3.2 before building the CHRE framework image, because the CHRE build depends on ANDROID_BUILD_TOP and the LLVM binary utilities, which are both exported by lunch:

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch evk_95-nxp_stable-userdebug
```

Then, run the following commands to build the CHRE framework image:

```
$ cd ${MY_ANDROID}/system/chre
$ CHRE_VARIANT_MK_INCLUDES=variant/cm7_freertos/variant.mk
 IS_ARCHIVE_ONLY_BUILD=true make nxp_cm7_freertos -j4
```

Then, the CHRE framework image can be generated: ${MY_ANDROID}/system/chre/out/nxp_cm7_freertos/libchre.a. Copy it to the specific directory so that it can be integrated into the CHRE MCU demo image when the CHRE MCU is built.

```
$ cp ${MY_ANDROID}/system/chre/out/nxp_cm7_freertos/libchre.a ${MY_ANDROID}/
system/chre/platform/freertos/libchre/
```

Alternatively, CHRE provides a helper build environment under ${MY_ANDROID}/system/chre/tools/dev, which sets up all the required environment variables automatically and builds the framework with size optimization (OPT_LEVEL=s). It creates its own Python 3 virtual environment, so pyenv is required:

```
$ sudo apt install -y libssl-dev zlib1g-dev libbz2-dev libreadline-dev
 libsqlite3-dev \
    wget curl llvm libncursesw5-dev xz-utils tk-dev libxml2-dev libxmlsec1-dev
 libffi-dev liblzma-dev
$ curl https://pyenv.run | bash
$ echo 'export PYENV_ROOT="$HOME/.pyenv"' >> ~/.bashrc
$ echo 'command -v pyenv >/dev/null || export PATH="$PYENV_ROOT/bin:$PATH"' >>
 ~/.bashrc
$ echo 'eval "$(pyenv init -)"' >> ~/.bashrc
$ source ~/.bashrc
```

Then, the CHRE framework image can be built with this helper build environment:

```
$ cd ${MY_ANDROID}/system/chre
$ source tools/dev/env_setup.sh
$ chre_lunch nxp-libchre
$ chre_make
```

chre_lunch asks for ANDROID_BUILD_TOP on the first run. Enter ${MY_ANDROID} for it. Then, it creates and activates a Python3 virtual environment under ~/.chre_dev/nxp-libchre. The generated CHRE

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framework image is `${MY_ANDROID}/system/chre/out/nxp_cm7_freertos/libchre.a`, which is the same as the one generated by the make command above.

The environment variables exported by `chre_lunch` are declared in `${MY_ANDROID}/system/chre/tools/dev/env_config.json`. If the Arm GNU BareMetal toolchain is not installed at the default location, modify the default value of `CORTEXM_TOOLS_PREFIX` in the `nxp` platform section according to the actual environment. `CHRE_TARGET_ELF_READER` is derived from `CORTEXM_TOOLS_PREFIX`, so it does not need to be modified.

```
{
    "platform": "nxp",
    "common_env_variables": [
    ...
    {
        "name": "CORTEXM_TOOLS_PREFIX",
        "type": "path",
        "description": "The path to the ARM GNU toolchain. ...",
        "default": "/opt/arm-gnu-toolchain-12.3.rel1-x86_64-arm-none-eabi"
    },
    {
        "name": "CHRE_TARGET_ELF_READER",
        "type": "file",
        "description": "The path to the elf reader provided by the toolchain",
        "default": "$CORTEXM_TOOLS_PREFIX/bin/arm-none-eabi-readelf"
    }
    ],
    ...
}
```

Alternatively, `chre_lunch` can be run in interactive mode to input the paths without modifying `env_config.json`. In this mode, it prompts for every environment variable, and pressing **Enter** keeps the default value displayed in the parentheses:

```
$ chre_lunch -i nxp-libchre
```

Note:

- *To know the directory structure and usages of the entire Git, see `${MY_ANDROID}/system/chre/README.md` and `${MY_ANDROID}/system/chre/doc`.*
- *For the i.MX platform implementation of CHRE, see this directory: `${MY_ANDROID}/system/chre/platform/freertos`.*
- *The main makefile related to the i.MX platform is: `${MY_ANDROID}/system/chre/build/variant/nxp_cm7_freertos.mk`.*
- *The static NanoApp is included in the CHRE framework image. Specify which NanoApps are included by default in the following file: `${MY_ANDROID}/system/chre/variant/cm7_freertos/static_nanoapps.cc`.*
- *If the Android build environment is not set up, export `ANDROID_BUILD_TOP` manually before the `make` command is executed. Otherwise, the build stops with the error "You should supply an ANDROID_BUILD_TOP".*
- *`chre_lunch` checks the existence of `llvm-strip`, which is provided by `${MY_ANDROID}/prebuilts/clang/host/linux-x86/llvm-binutils-stable` and added into `PATH` by `lunch`. Note that `sudo apt install llvm` only provides the versioned binary such as `llvm-strip-14` on Ubuntu 22.04, which does not meet this check.*
- *The `libchre` target generates a static library instead of a shared library, so `chre_make` ends with the message "Warn: .so file does not exist: ./out/nxp_cm7_freertos/*.so, don't build so" and returns a non-zero value. This is expected. The build is successful as long as "[AR] out/nxp_cm7_freertos/libchre.a" is printed.*

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12.1.2 Building the preloaded NanoApp

NanoApps are applications written in C or C++, which run in CHRE to use low-power hardware. The preloaded NanoApps are built as a separate binary from the CHRE framework, but included in the vendor partition. To obtain the detailed introduction of NanoApp, see `${MY_ANDROID}/system/chre/doc/nanoapp_overview.md`. The information about the preloaded NanoApp is provided in `${MY_ANDROID}/device/nxp/imx9/evk_95/chre/preloaded_nanoapps.json` as follows:

```
{
  "source_dir": "/vendor/etc/chre",
  "nanoapps": [
    "hello_world",
  ]
}
```

The preloaded NanoApps are cross-compiled with the same host packages, Arm GNU BareMetal toolchain, and Android build environment as the CHRE framework image. See Section 12.1.1 for these prerequisites. Set `CORTEXM_TOOLS_PREFIX` according to the actual toolchain installation directory if the toolchain is not installed at the default location.

To build a preloaded NanoApp, such as the `hello_world` NanoApp, run the following commands:

```
$ cd ${MY_ANDROID}/system/chre/apps/hello_world
$ make nxp_cm7_freertos -j4
```

Then, the NanoApp is generated in this directory: `${MY_ANDROID}/system/chre/apps/hello_world/out/nxp_cm7_freertos`.

Alternatively, the helper build environment under `${MY_ANDROID}/system/chre/tools/dev` can also be used to build the preloaded NanoApp. Besides setting up the required environment variables, it also strips the unnecessary symbols from the NanoApp binary, checks whether the NanoApp has any undefined symbols, and reports the final binary size.

```
$ cd ${MY_ANDROID}/system/chre/apps/hello_world
$ source ${MY_ANDROID}/system/chre/tools/dev/env_setup.sh
$ chre_lunch nxp-nanoapp
$ chre_make
```

The environment variables of the NanoApp target are also declared in the `nxp` platform section of `${MY_ANDROID}/system/chre/tools/dev/env_config.json`, and are cached into `~/.chre_dev/nxp-nanoapp/env_vars.txt`. For how to configure them according to the actual environment, see Section 12.1.1.

To integrate the preloaded NanoApp into the Android system, run the following commands:

```
$ cp \
  ${MY_ANDROID}/system/chre/apps/hello_world/out/nxp_cm7_freertos/hello_world.so
 \
  ${MY_ANDROID}/system/chre/apps/hello_world/out/nxp_cm7_freertos/
hello_world.napp_header \
  ${MY_ANDROID}/system/chre/apps/dynamic_nanoapps/

    Refer to the following code to modify ${MY_ANDROID}/system/chre/apps/
dynamic_nanoapps/Android.bp
    prebuilt_etc {
    name: "hello_world.so",
    sub_dir: "chre",
    vendor: true,
    srcs: [
```


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```
"hello_world.so",
],
}

    prebuilt_etc {
    name: "hello_world.napp_header",
    sub_dir: "chre",
    vendor: true,
    srcs: [
"hello_world.napp_header",
],
}
```

Note:

- *If the Android build environment is not set up, export `ANDROID_BUILD_TOP` manually before the `make` command is executed. Otherwise, the build stops with the error "You should supply an ANDROID_BUILD_TOP".*
- *No NanoApp signer is configured for the i.MX platform, so `chre_make` prints the message "No signer configured for platform 'nxp'. Skipping signing." This is expected.*

12.2 Building the MCU CHRE demo

The CHRE framework image is linked into the MCU CHRE demo image as a static library. After the CHRE framework image is updated, the MCU CHRE demo image also needs to be rebuilt and copied to the prebuilt directory. To build the MCU CHRE demo image, install West first using the following commands:

```
$ sudo apt update
$ sudo apt install python3-pip python3-setuptools python3-wheel -y
$ pip3 install --user west
```

West is installed to `~/.local/bin` by default. If the `west` command is not found, add this path to `$PATH`:

```
$ echo 'export PATH=$HOME/.local/bin:$PATH' >> ~/.bashrc
$ source ~/.bashrc
$ west --version  # verify
```

If you encounter the installation failure due to version issues, you can try installing through a virtual environment using `venv`:

```
$ sudo apt update
$ sudo apt install python3-venv -y  # install venv
$ python3 -m venv ~/west-env        # create venv
$ source ~/west-env/bin/activate    # start venv
$ (west-env)$ pip install west      # install west in west-env
$ (west-env)$ west --version        # check the version of west in venv
```

The West installation typically resides in `$HOME/west-env/bin/` within `venv`. You can use the following commands to use the West from `venv` by default.

```
$ echo 'alias west="$HOME/west-env/bin/west"' >> ~/.bashrc
$ source ~/.bashrc
$ west --version   # verify
```


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After West is installed, use the following commands to build the MCU CHRE demo image:

```
$ cd ${MY_ANDROID}/vendor/nxp/mcu-sdk/imx95/mcuxsdk
$ export ARMGCC_DIR=/path/to/gcc-arm-none-eabi
$ west build -b imx95lpd5evk19 examples/demo_apps/rpmsg_chre_demo_imx95 --
toolchain armgcc -Dcore_id=cm7 -p always
$ cp ${MY_ANDROID}/vendor/nxp/mcu-sdk/imx95/mcuxsdk/build/
rpmsg_chre_demo_imx95_cm7.bin \
${MY_ANDROID}/vendor/nxp/fsl-proprietary/mcu-sdk/imx95/
imx95_19x19_mcu_demo_chre.img
```

12.3 Building the Android image with CHRE

You can use the following commands to generate the Android image containing CHRE:

```
$ cd ${MY_ANDROID}
$ source build/envsetup.sh
$ lunch evk_95-nxp_stable-userdebug
$ ENABLE_CONTEXTHUB=true ./imx-make.sh -j4
```

After the build process is complete, you can find target files in the following paths:

- `${MY_ANDROID}/out/target/product/evk_95/vendor/bin/hw/android.hardware.contexthub-service.imx`
- `${MY_ANDROID}/out/target/product/evk_95/vendor/etc/chre/preloaded_nanoapps.json`
- `${MY_ANDROID}/out/target/product/evk_95/vendor/etc/chre/hello_world.so`
- `${MY_ANDROID}/out/target/product/evk_95/vendor/etc/chre/hello_world.napp_header`

13 Acronyms

Table 30. Acronyms

Acronym	Description
ADB	Android Debug Bridge
AOSP	Android Open Source Project
AVB	Android Verified Boot
BT	Bluetooth
CAAM	Cryptographic Acceleration and Assurance Module
CMA	Contiguous Memory Allocator
CPU	Central Processing Unit
CST	(NXP) Code Signing Tool
DTS	Device Tree Source
eMMC	Embedded Multi-Media Card
EVK	Evaluation Kit
GCC	GNU Compiler collection
GPT	GUID partition table
MCU	Microcontroller Unit
MEK	Multisensory Enablement Kit

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Table 30. Acronyms...*continued*

Acronym	Description
OS	Operating system
OTA	Over-The-Air programming
PC	Personal (host) computer
RAM	Random Access Memory
RPMB	Replay Protected Memory Block
SoC	System on Chip
SPL	U-Boot Secondary Program Loader
TEE	Trusted Execution Environment
U-Boot	Universal Boot Loader
UUU	Universal Update Utility

14 Note about the source code in the document

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15 Revision history

Revision history

Document ID	Release date	Description
UG10156 v.android-17.0.0_1.0.0	3 November 2026	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus, i.MX 95, i.MX 952 GA release, and FRDM-IMX937 Beta release.
UG10156 v.android-16.0.0_2.0.0	19 August 2026	Corrected a typo in the command line in Section 8.4.1.

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Revision history...*continued*

Document ID	Release date	Description
UG10156 v.android-16.0.0_2.0.0	24 July 2026	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus, i.MX 95 GA release, and i.MX 952 Beta release.
UG10156 v.android-16.0.0_1.4.0	1 April 2026	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus, and i.MX 95 GA release.
UG10156 v.android-16.0.0_1.2.0	6 January 2026	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus, and i.MX 95 GA release.
UG10156 v.android-16.0.0_1.0.0	28 October 2025	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus GA release, and i.MX 95 Beta release.
UG10156 v.android-15.0.0_2.0.0	24 July 2025	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus GA release, i.MX 95 19x19 EVK Beta release, and i.MX 95 15x15 EVK Alpha release.
UG10156 v.android-15.0.0_1.2.0	16 May 2025	Updated the codes for GKI export new symbols build in Section 9.4 due to the update of the Google AOSP GKI code.
UG10156 v.android-15.0.0_1.2.0	11 April 2025	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus GA release, and i.MX 95 Beta release.
UG10156 v.android-15.0.0_1.0.0	24 January 2025	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus GA release, and i.MX 95 Beta release.
UG10156 v.android-14.0.0_2.2.0	15 November 2024	Corrected the command lines to generate the symbol list when GKI is used. See Section 9.4.
UG10156 v.android-14.0.0_2.2.0	18 October 2024	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus GA release, i.MX 95 (A1 15x15) Alpha release, and i.MX 95 (A1 19x19) Beta release.
UG10156 v.android-14.0.0_2.0.0	9 August 2024	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8ULP, i.MX 8QuadMax, i.MX 8QuadXPlus GA release, and i.MX 95 Alpha release. Updated the document ID.
AUG v.android-14.0.0_1.2.0	19 April 2024	i.MX 8ULP EVK, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8Quad XPlus GA release.
AUG v.android-14.0.0_1.0.0	6 February 2024	i.MX 8ULP EVK, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8Quad XPlus GA release.
AUG v.android-13.0.0_2.2.0	24 October 2023	i.MX 8ULP EVK, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8Quad XPlus GA release.
AUG v.android-13.0.0_2.0.0	07/2023	i.MX 8ULP EVK Beta release, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8 QuadXPlus GA release.

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Revision history...*continued*

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AUG v.android-13.0.0_1.2.0	03/2023	i.MX 8ULP EVK Beta release, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8 QuadXPlus GA release.
AUG v.android-13.0.0_1.0.0	01/2023	i.MX 8ULP EVK Beta release, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8 QuadXPlus GA release.
AUG v.android-12.1.0_1.0.0	10/2022	i.MX 8ULP EVK Beta release, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8 QuadXPlus GA release.
AUG v.android-12.0.0_2.0.0	07/2022	i.MX 8ULP EVK Beta release, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, and i.MX 8M Quad GA release.
AUG v.android-12.0.0_1.0.0	03/2022	i.MX 8ULP EVK Beta release, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, and i.MX 8M Quad GA release.
AUG v.android-11.0.0_2.6.0	01/2022	i.MX 8ULP EVK Beta release, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, and i.MX 8M Quad GA release.
AUG v.android-11.0.0_2.4.0	10/2021	i.MX 8ULP EVK Alpha release, i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, and i.MX 8M Quad GA release.
AUG v.android-11.0.0_2.2.0	07/2021	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, and i.MX 8M Quad GA release.
AUG v.android-11.0.0_2.0.0	04/2021	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Plus, and i.MX 8M Quad GA release.
AUG v.android-11.0.0_1.0.0	12/2020	i.MX 8M Plus EVK Beta release, and all the other i.MX 8 GA release.
AUG v.android-10.0.0_2.3.0	07/2020	i.MX 8M Plus EVK Beta1 release, and all the other i.MX 8 GA release.
AUG v.android-10.0.0_2.0.0	05/2020	i.MX 8M Mini, i.MX 8M Nano, i.MX 8M Quad, i.MX 8Quad Max, and i.MX 8QuadXPlus GA release.
AUG v.android-10.0.0_2.1.0	04/2020	i.MX 8M Plus Alpha and i.MX 8QuadXPlus Beta release.
AUG v.android-10.0.0_1.0.0	03/2020	Deleted the Android 10 image.
AUG v.android-10.0.0_1.0.0	02/2020	i.MX 8M Mini, i.MX 8M Quad, i.MX 8QuadMax, and i.MX 8 QuadXPlus GA release.
AUG v.P9.0.0_2.0.0-ga	08/2019	Updated the location of the SCFW porting kit.
AUG v.P9.0.0_2.0.0-ga	04/2019	i.MX 8M, i.MX 8QuadMax, i.MX 8QuadXPlus GA release.
AUG v.P9.0.0_1.0.0-ga	01/2019	i.MX 8M, i.MX 8QuadMax, i.MX 8QuadXPlus GA release.
AUG v.P9.0.0_1.0.0-beta	11/2018	Initial release

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