SC60 Camera Driver Development Guide

Smart LTE Module Series

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About the Document

History

Revision	Date	Author	Description
1.0	2018-04-08	Barnett WANG	Initial

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1 Introduction

This document provides driver development guidelines for the camera module (such as the camera sensor), and describes how to bring up the camera on the MSM8953 Android platform of Quectel SC60 module.

The camera sensor framework includes the configuration of the following components:

- Sensor
- CSIPHY
- CSID
- Actuator
- Flash
- EEPROM
- Chromatix™

NOTE

We will use the main camera S5K3P3 on SC60's EVB (Smart EVB G2) as an example in this document.

2 Information Provided by Camera Module Manufacturers

The camera module manufacturers should provide:

1. Sensor datasheet, AF datasheet (if camera module has AF)
2. User-space sensor driver
3. Sensor chromatix code
4. User-space AF actuator driver
5. AF actuator effect code
6. User-space EEPROM driver

Take the main camera S5K3P3 on EVB as an example, the following are all provided by the manufacturer:

1. User-space sensor driver and sensor chromatix code

vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors:
sensor/libs/s5k3p3/
├─── Android.mk
├─── s5k3p3_lib.c
└─── s5k3p3_lib.h
chromatix/0309/chromatix_s5k3p3/
├─── 3A
│ ├─── default_preview
│ ├─── default_video
│ ├─── hfr_120
│ ├─── hfr_60
│ ├─── hfr_90
│ ├─── zsl_preview
│ └─── zsl_video
├─── common
├─── cpp
│ ├─── cpp_hfr_120
│ ├─── cpp_hfr_60
│ ├─── cpp_hfr_90
│ ├─── cpp_liveshot
│ ├─── cpp_preview

```
│   ├── cpp_snapshot
│   └── cpp_video
├── isp
│   ├── hfr_120
│   ├── hfr_60
│   ├── hfr_90
│   ├── preview
│   ├── snapshot
│   └── video
└── postproc
```

2. User-space AF actuator driver

vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/actuator/libs/dw9763/

```
├── Android.mk
├── dw9763_actuator.c
└── dw9763_actuator.h
```

3. User-space EEPROM driver

vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/eeprom/libs/dw9763_2d/

```
├── Android.mk
├── dw9763_2d_eeprom.c
└── dw9763_2d_eeprom.h
```

3 Camera Circuit Diagram

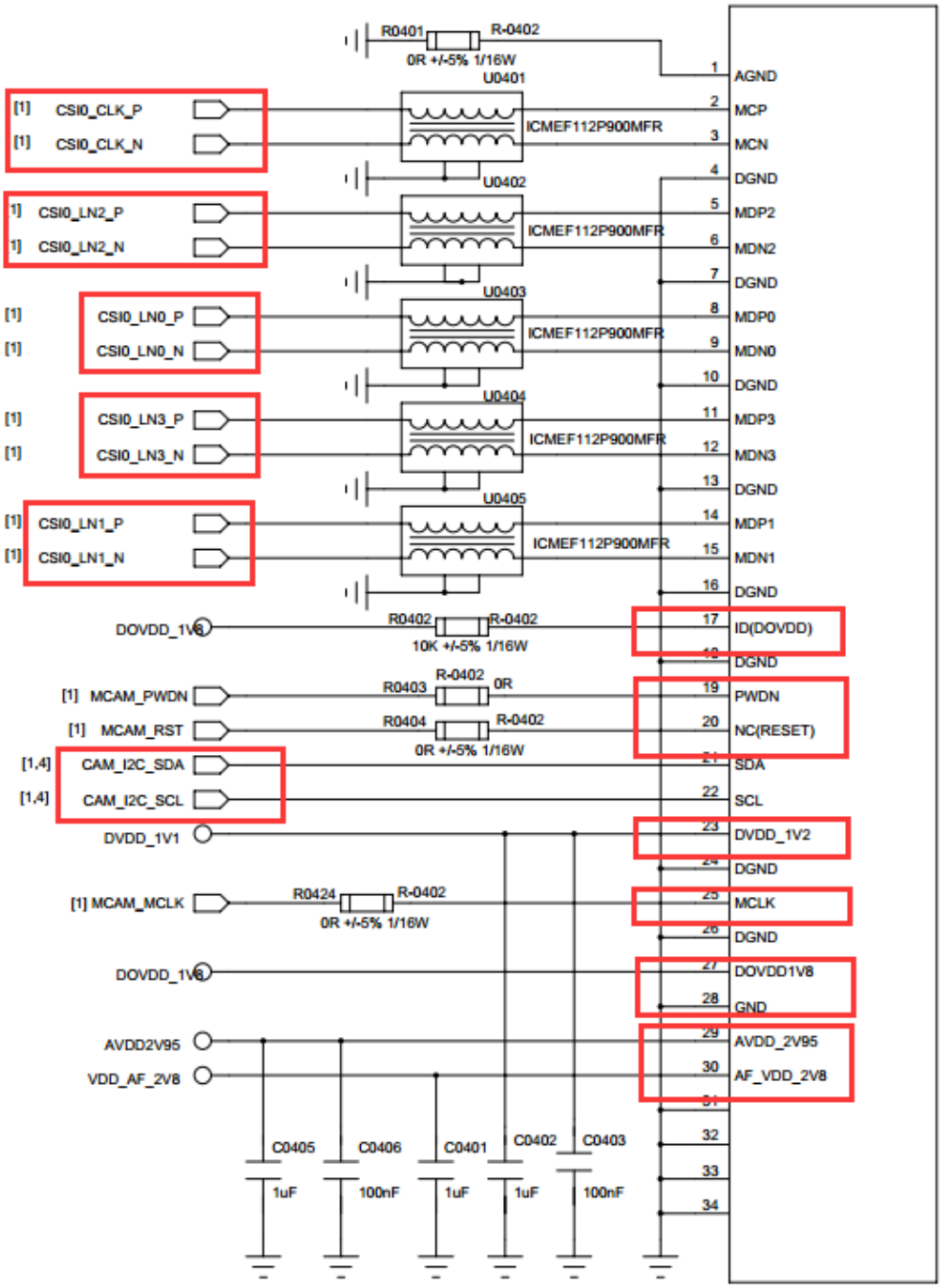


Figure 1: Main Camera Circuit Diagram

- Power supply: DVDD (1.2V), AVDD (2.8V), IOVDD (1.8V) (DOVDD), AFVDD (2.8V)
- Reset: RESET
- Suspend: PWDN
- Clock: MCLK
- MIPI Data: MDP0 MDN0, MDP1 MDN1, MDP2 MDN2, MDP3 MDN3
- MIPI Clock: MCP, MCN
- I2C: SDA, SCL

NOTE

I2C: Qualcomm CCI interface. It is only used for camera.

While debugging sensor, we need to configure the MCLK, power supply, and the power sequence first.

- The sensor's power supply pins are mainly DVDD (1.2V), AVDD (2.8V) and IOVDD (1.8V). While AFVDD (2.8V) is not the power supply pin of camera sensor, it's for actuator.
- RESET and PWDN pins are also associated with power on sequence. Sometimes, the PWDN pin is not available for the camera module circuit design/connection, and is internally pull-up.

NOTE

After power, MCLK, and power-on sequence are all configured, the sensor will work properly. Thus, SC60 will be able to communicate with the sensor by I2C, and then can read the ID from the sensor ID register.

4 Add Sensor Driver

4.1. Kernel Driver

This section provides the information necessary for adding the kernel driver.

Path: *kernel/msm-3.18/arch/arm/boot/dts/qcom/msm8953-camera-sensor-mtp.dtsi*

4.1.1. GPIO Configuration

As shown below, the customer can configure sensor-specific GPIOs based on the target board.

For explanations on each property, please refer to documents in the following path:
kernel/msm-3.18/Documentation/devicetree/bindings/video/

GPIOs can be configured by the following two ways, based on the software being used.

1. Using pinctrl

Pinctrl node entries in .dtsi file can be used to configure GPIOs, e.g.:

```
pinctrl-names = "cam_default", "cam_suspend";
pinctrl-0 = <&cam_sensor_mclk0_default &cam_sensor_rear_default>;
pinctrl-1 = <&cam_sensor_mclk0_sleep &cam_sensor_rear_sleep>;
```

2. Using GPIO control

GPIO node entries in .dtsi file can be used to configure GPIOs, e.g.:

```
gpios = <&msm_gpio 26 0>,
        <&msm_gpio 35 0>,
        <&msm_gpio 34 0>;
qcom,gpio-reset = <1>;
qcom,gpio-standby = <2>;
qcom,gpio-req-tbl-num = <0 1 2>;
qcom,gpio-req-tbl-flags = <1 0 0>;
qcom,gpio-req-tbl-label = "CAMIF_MCLK",
```

```
"CAM_RESET1",
"CAM_STANDBY";
```

4.1.2. Clock-related Settings

In the .dts file, for each sensor node, the customer can configure clock source as follows:

```
clocks = <&clock_gcc clk_mclk0_clk_src>,
         <&clock_gcc clk_gcc_camss_mclk0_clk>;
clock-names = "cam_src_clk", "cam_clk";
```

The order of the lists in the two properties is important. The nth clock-name will correspond to the nth entry in the clock's property. Thus, the two properties above, cam_src_clk would correspond to clk_mclk0_clk_src, cam_clk should correspond to clk_gcc_camss_mclk0_clk, etc. The customer does not need to change this, as it is parsed in the clock framework.

4.1.3. Power Handler

1. PMIC case

```
cam_vio-supply = <&pm8953_l6>;
cam_vdig-supply = <&pm8953_l2>;
cam_vaf-supply = <&pm8953_l17>;
cam_vana-supply = <&pm8953_l22>;
qcom,cam-vreg-name = "cam_vio", "cam_vdig", "cam_vaf",
                     "cam_vana";
qcom,cam-vreg-min-voltage = <0 1100000 2850000 2800000>;
qcom,cam-vreg-max-voltage = <0 1100000 2850000 2800000>;
qcom,cam-vreg-op-mode = <0 105000 100000 80000>;
```

2. GPIO case

```
gpios = <&tlmm 26 0>,
    <&tlmm 40 0>,
    <&tlmm 39 0>,
    <&tlmm 3 0>;
qcom,gpio-reset = <1>;
qcom,gpio-standby = <2>;
qcom,gpio-vdig = <3>;
qcom,gpio-req-tbl-num = <0 1 2 3>;
qcom,gpio-req-tbl-flags = <1 0 0 0>;
qcom,gpio-req-tbl-label = "CAMIF_MCLK0",
    "CAM_RESET0",
    "CAM_STANDBY0",
    "CAM_VDIG";
```

- CAM_VANA – Supply voltage (analog)
- CAM_VDIG – Supply voltage (digital)
- CAM_VIO – Input/output voltage (digital)
- CAM_VAF – Supply voltage (actuator voltage)

4.1.4. Using EVB's Main Camera S5K3P3 as an Example

- DVDD: gpio3 control
- AVDD: LDO22 supply
- IOVDD: LDO6 supply
- RESET: gpio40 control
- PWDN: gpio39 control

The power supply type can be LDO supply or GPIO control, so there are two places needing configuration.

In the following example codes, vdig configures not only LDO2 but also GPIO3. But actually only GPIO3 needs to be configured.

- *kernel/msm-3.18/arch/arm/boot/dts/qcom/msm8953-camera-sensor-mtp.dtsi*

```
/*Main Camera*/
qcom,camera@0 {
    cell-index = <0>;
    compatible = "qcom,camera";
    reg = <0x0>;
    qcom,csiphy-sd-index = <0>;
    qcom,csid-sd-index = <0>;
    qcom,mount-angle = <270>;
    qcom,led-flash-src = <&led_flash0>;
    qcom,eeprom-src = <&eeprom0>;
    qcom,actuator-src = <&actuator0>;
    cam_vio-supply = <&pm8953_l6>;          IOVDD
    cam_vdig-supply = <&pm8953_l2>;         DVDD
    cam_vaf-supply = <&pm8953_l17>;
    cam_vana-supply = <&pm8953_l22>;        AVDD
    qcom,cam-vreg-name = "cam_vio", "cam_vdig", "cam_vaf",
                         "cam_vana";
    qcom,cam-vreg-min-voltage = <0 1100000 2850000 2800000>;
    qcom,cam-vreg-max-voltage = <0 1100000 2850000 2800000>;
    qcom,cam-vreg-op-mode = <0 105000 100000 80000>;
    pinctrl-names = "cam_default", "cam_suspend";
    pinctrl-0 = <&cam_sensor_mclk0_default
            &cam_sensor_rear_default
            &cam_sensor_rear_vana>;
    pinctrl-1 = <&cam_sensor_mclk0_sleep &cam_sensor_rear_sleep
            &cam_sensor_rear_vana_sleep>;
    gpios = <&tlmm 26 0>,
        <&tlmm 40 0>,
        <&tlmm 39 0>,
        <&tlmm 3 0>;
    qcom,gpio-reset = <1>;          RESET
    qcom,gpio-standby = <2>;        PWDN
    qcom,gpio-vdig = <3>;           DVDD
    qcom,gpio-req-tbl-num = <0 1 2 3>;
    qcom,gpio-req-tbl-flags = <1 0 0 0>;
    qcom,gpio-req-tbl-label = "CAMIF_MCLK0",
        "CAM_RESET0",
        "CAM_STANDBY0",
        "CAM_VDIG";
```

- *kernel/msm-3.18/arch/arm/boot/dts/qcom/msm8953-pinctrl.dtsi*

```
cam_sensor_rear_default: cam_sensor_rear_default {
    /* RESET, STANDBY */
    mux {
        pins = "gpio40", "gpio39";
        function = "gpio";
    };

    config {
        pins = "gpio40","gpio39";
        bias-disable; /* No PULL */
        drive-strength = <2>; /* 2 MA */
    };
};

cam_sensor_rear_sleep: cam_sensor_rear_sleep {
    /* RESET, STANDBY */
    mux {
        pins = "gpio40","gpio39";
        function = "gpio";
    };

    config {
        pins = "gpio40","gpio39";
        bias-disable; /* No PULL */
        drive-strength = <2>; /* 2 MA */
    };
};
```

```
cam_sensor_rear_vdig: cam_sensor_rear_vdig {
    /* VDIG */
    mux {
        pins = "gpio3";
        function = "gpio";
    };

    config {
        pins = "gpio3";
        bias-disable; /* No PULL */
        output-low;
        drive-strength = <2>; /* 2 MA */
    };
};

cam_sensor_rear_vdig_sleep: cam_sensor_rear_vdig_sleep {
    /* VDIG */
    mux {
        pins = "gpio3";
        function = "gpio";
    };

    config {
        pins = "gpio3";
        bias-disable; /* No PULL */
        drive-strength = <2>; /* 2 MA */
    };
};
```

4.2. User Space Driver

This section describes information necessary for creating the user space driver.

The sensor's user space driver should be provided by the camera module manufacturer. We only show the important parts such as the sensor driver and chromatix code in this section.

4.2.1. Sensor Driver

1. Add sensor driver

Refer to *s5k3p3_lib.c*, *s5k3p3_lib.h*, *s5k3p3_pdaf_flip_mirror.h*, *s5k3p3_pdaf.h*, and *Android.mk files* in: *vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/sensor/libs/s5k3p3/*

2. Configure driver

- Generally, there is no need to modify these parameters, as the manufacture has configured them already.
- Configure camera ID, slaver address, sensor ID

  After power-on, the driver will read the sensor ID. If it is successfully matched, it will probe successfully.

```
static sensor_lib_t sensor_lib_ptr =
{
  .sensor_slave_info =
  {
    .sensor_name = SENSOR_MODEL,
    .slave_addr = 0x20,
    .i2c_freq_mode = SENSOR_I2C_MODE_FAST,
    .addr_type = CAMERA_I2C_WORD_ADDR,
    .sensor_id_info =
    {
      .sensor_id_reg_addr = 0x0000,
      .sensor_id = 0x3103,
    },
```

3. Configure sensor output information

- It supports sensor format raw8/raw10/raw12/raw14

```
  .sensor_output =
  {
    .output_format = SENSOR_BAYER,
    .connection_mode = SENSOR_MIPI_CSI,
    .raw_output = SENSOR_10_BIT_DIRECT,
#ifndef FLIP_MIRROR
    .filter_arrangement = SENSOR_GRBG,
#else
    .filter_arrangement = SENSOR_GBRG,
#endif
  },
```

NOTE

Qualcomm documentation did not specify the sensor format information, and we have only verified format raw10.

- Configure the register

  It mainly includes: init register array, start/stop register array, resolution register array.

```
  .res_settings_array =
  {
    .reg_settings =
    {
      /* Res 0 */
      {
        .reg_setting_a = RES0_REG_ARRAY,
        .addr_type = CAMERA_I2C_WORD_ADDR,
        .data_type = CAMERA_I2C_WORD_DATA,
        .delay = 0,
      },
#ifndef DISABLE_RES1_TO_USE_PDAF_IN_VIDEO_OR_NOZSL_MODE
      /* Res 1 */
      {
        .reg_setting_a = RES1_REG_ARRAY,
        .addr_type = CAMERA_I2C_WORD_ADDR,
        .data_type = CAMERA_I2C_WORD_DATA,
        .delay = 0,
      },
#endif
```

```
  .out_info_array =
  {
    .out_info =
    {
      /* Res 0 */
      {
        .x_output = 4632,
        .y_output = 3480,
        .line_length_pclk = 5148,
        .frame_length_lines = 3626,
        .vt_pixel_clk = 560000000,
        .op_pixel_clk = 556800000,
        .binning_factor = 1,
        .min_fps = 4,//7.5
        .max_fps = 30.1,
        .mode = SENSOR_DEFAULT_MODE,
        .offset_x = 0,
        .offset_y = 0,
        .scale_factor = 0,
        .is_pdaf_supported = 1,//when the pdaf cal data
into snashot camera,
                              //and the third camera apk c
      },
#ifndef DISABLE_RES1_TO_USE_PDAF_IN_VIDEO_OR_NOZSL_MODE
      /* Res 1 */
      {
        .x_output = 2316,
        .y_output = 1740,
        .line_length_pclk = 5148,
        .frame_length_lines = 3626,
        .vt_pixel_clk = 560000000,
        .op_pixel_clk = 556800000,
        .binning_factor = 1,
        .min_fps = 7.5,
        .max_fps = 30.1,
        .mode = SENSOR_DEFAULT_MODE,
        .offset_x = 0,
        .offset_y = 0,
        .scale_factor = 0,
        .is_pdaf_supported = 0,
      },
#endif
```

NOTE

Resolution/CLK/Frame need correspond with register configuration.

- Configure lane number

```
.csi_params =
{
  .lane_cnt = 4,
  .settle_cnt = 0x14,
  .is_csi_3phase = 0,
},
```

4. Configure power on/off sequence

- Power on sequence

S5K3P3 datasheet describes the power-on sequence as below:

7.1 Power-Up Sequence

The digital and analog supply voltages can be powered up in any order, e.g., VDDD/VDDIO then VDDA/VPIX or VDDA/VPIX/VDDIO then VDDD.

On power up, RSTN (XSHUTDOWN) should be low when the power supplies are brought up, then the sensor module will go into hardware standby mode. As long as RSTN is low and VDDD is down, the sensor module stays in hardware standby mode.

The assertion of RSTN ensures that the CCI/SPI register values are initialized correctly to their default values.

When RSTN will go "high", all PADs will exit from FAIL-SAFE mode, and switch to Normal operating mode.

The MCLK clock can either be initially low and then enabled during software standby mode or MCLK can be a free running clock.

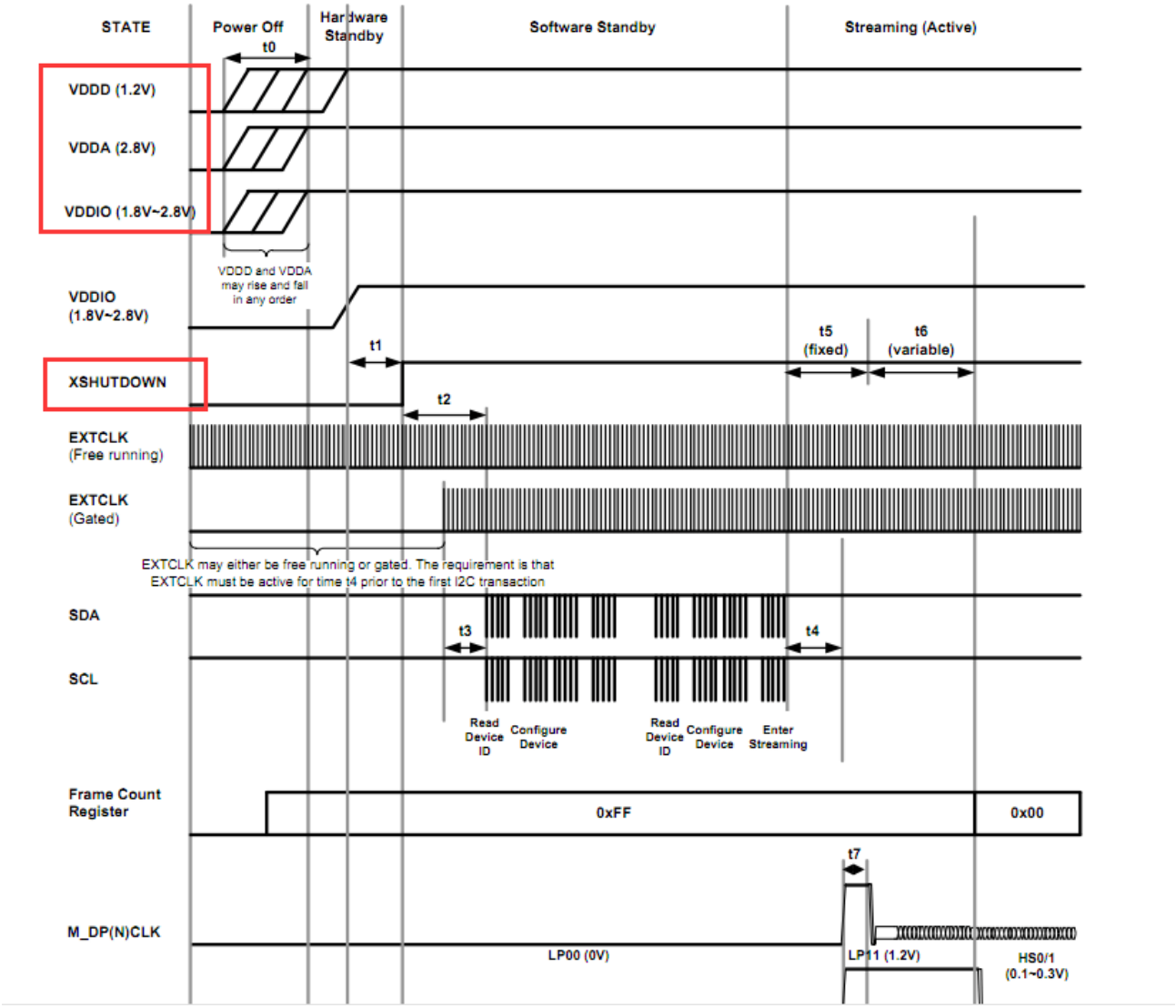


Figure 2: S5K3P3 Power on Sequence

Power on AVDD first, and then IOVDD and DVDD. Wait t1 time, pull up XPWRDWN (PWDN).

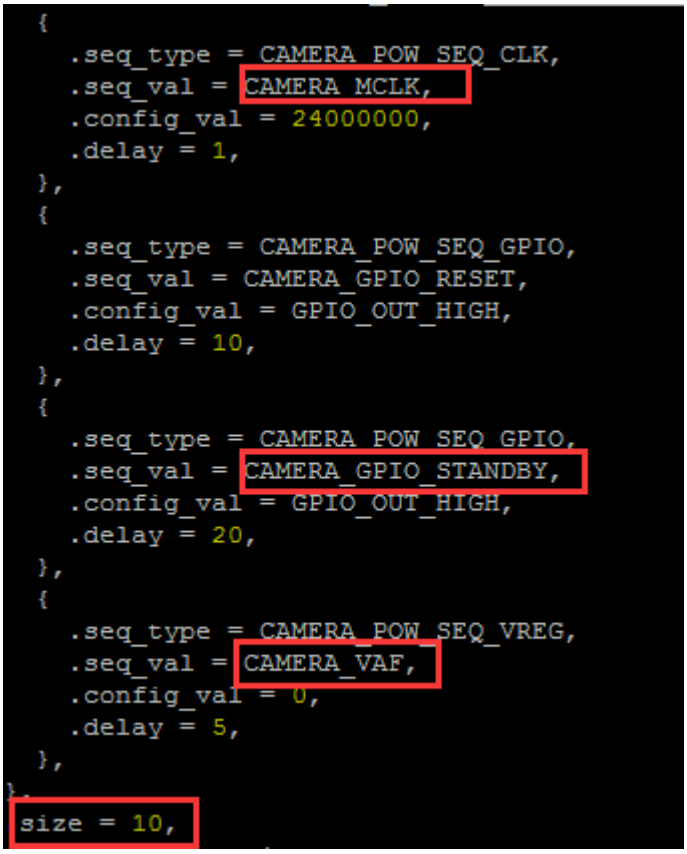
NOTE

Sometimes, there is no need to strictly conform to the power on sequence, but sometimes it is a must. So we had better configure the power on sequence according to the datasheet. Otherwise, maybe the camera can not be brought up.

- Power on sequence in code

Path:
vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/sensor/libs/s5k3p3/s5k3p3_lib.h

```
.power_setting_array =
{
  .power_setting_a =
  {
    {
      .seq_type = CAMERA_POW_SEQ_GPIO,
      .seq_val = CAMERA_GPIO_RESET,
      .config_val = GPIO_OUT_LOW,
      .delay = 1,
    },
    {
      .seq_type = CAMERA_POW_SEQ_GPIO,
      .seq_val = CAMERA_GPIO_STANDBY,
      .config_val = GPIO_OUT_LOW,
      .delay = 1,
    },
    {
      .seq_type = CAMERA_POW_SEQ_VREG,
      .seq_val = CAMERA_VANA,
      .config_val = 0,
      .delay = 1,
    },
    {
      .seq_type = CAMERA_POW_SEQ_VREG,
      .seq_val = CAMERA_VIO,
      .config_val = 0,
      .delay = 1,
    },
    {
      .seq_type = CAMERA_POW_SEQ_VREG,
      .seq_val = CAMERA_VDIG,
      .config_val = 0,
      .delay = 5,
    },
    {
      .seq_type = CAMERA_POW_SEQ_GPIO,
      .seq_val = CAMERA_GPIO_VDIG,
      .config_val = GPIO_OUT_HIGH,
      .delay = 5,
    },
```



- Power off sequence

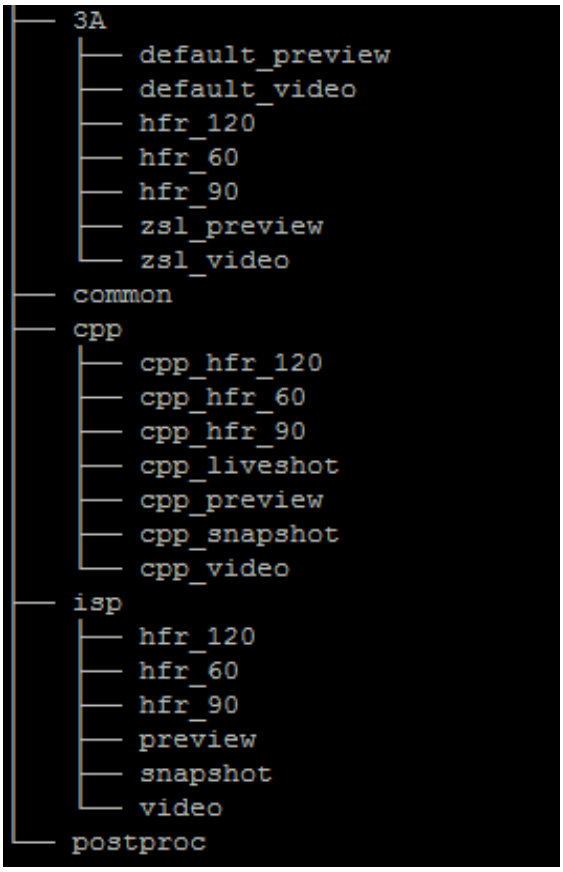
Please refer to the power on sequence.

4.2.2. Chromatix Code

1. Adding chromatix code

Path:
vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/chromatix/0309/chromatix_s5k3p3

Compile the codes in above path to generate .so files, and then configure the .so files by:
vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/configs/s5k3p3_chromatix.xml



2. Configure to use chromatix code

- Add the file in the following path: vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/configs/s5k3p3_chromatix.xml
- ISP/CPP/3A code should be configured corresponding to sensor resolution index in the path below: *vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/sensor/libs/s5k3p3/s5k3p3_lib.h*

```
<ChromatixConfigurationRoot>
  <CommonChromatixInfo>
    <ChromatixName special_mode_mask="0">
      <ISPCommon>s5k3p3_common</ISPCommon>
      <PostProc>s5k3p3_postproc</PostProc>
    </ChromatixName>
  </CommonChromatixInfo>
  <ResolutionChromatixInfo>
    <ChromatixName sensor_resolution_index="0">
      <ISPPreview>s5k3p3_snapshot</ISPPreview>
      <ISPSnapshot>s5k3p3_snapshot</ISPSnapshot>
      <ISPVideo>s5k3p3_snapshot</ISPVideo>
      <CPPPreview>s5k3p3_cpp_preview</CPPPreview>
      <CPPSnapshot>s5k3p3_cpp_snapshot</CPPSnapshot>
      <CPPVideo>s5k3p3_cpp_video</CPPVideo>
      <CPPLiveshot>s5k3p3_cpp_liveshot</CPPLiveshot>
      <A3Preview>s5k3p3_zsl_preview_dw9763</A3Preview>
      <A3Video>s5k3p3_zsl_video_dw9763</A3Video>
    </ChromatixName>
    <ChromatixName sensor_resolution_index="1">
      <ISPPreview>s5k3p3_snapshot</ISPPreview>
      <ISPSnapshot>s5k3p3_snapshot</ISPSnapshot>
      <ISPVideo>s5k3p3_snapshot</ISPVideo>
      <CPPPreview>s5k3p3_cpp_preview</CPPPreview>
      <CPPSnapshot>s5k3p3_cpp_snapshot</CPPSnapshot>
      <CPPVideo>s5k3p3_cpp_video</CPPVideo>
      <CPPLiveshot>s5k3p3_cpp_liveshot</CPPLiveshot>
      <A3Preview>s5k3p3_default_preview_dw9763</A3Preview>
      <A3Video>s5k3p3_default_video_dw9763</A3Video>
    </ChromatixName>
    <ChromatixName sensor_resolution_index="2">
      <ISPPreview>s5k3p3_hfr_60</ISPPreview>
      <ISPSnapshot>s5k3p3_hfr_60</ISPSnapshot>
      <ISPVideo>s5k3p3_hfr_60</ISPVideo>
      <CPPPreview>s5k3p3_cpp_hfr_60</CPPPreview>
      <CPPSnapshot>s5k3p3_cpp_hfr_60</CPPSnapshot>
      <CPPVideo>s5k3p3_cpp_hfr_60</CPPVideo>
      <CPPLiveshot>s5k3p3_cpp_hfr_60</CPPLiveshot>
      <A3Preview>s5k3p3_hfr_60_dw9763</A3Preview>
      <A3Video>s5k3p3_hfr_60_dw9763</A3Video>
    </ChromatixName>
```

- Modify the file in the following path:
  vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/configs/Android.mk

```
include $(CLEAR_VARS)
LOCAL_MODULE:= s5k3p3_chromatix.xml
LOCAL_MODULE_CLASS := EXECUTABLES
LOCAL_SRC_FILES := s5k3p3_chromatix.xml
LOCAL_MODULE_TAGS := optional
LOCAL_MODULE_PATH := $(TARGET_OUT)/etc/camera
LOCAL_MODULE_OWNER := qti
include $(BUILD_PREBUILT)
```

4.2.3. Driver Configuration

1. Xml configuration

Path:

vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/configs/msm8953_camera.xml

Main parameters:

CameraId: 0, 1, 2
CSIDCore: 0, 1, 2
These two patameters correspond to *qcom,camera@0*, *qcom,camera@1* and *qcom,camera@2* in *kernel/msm-3.18/arch/arm/boot/dts/qcom/msm8953-camera-sensor-mtp.dtsi*.

Position:
BACK, FRONT and BACK_AUX
(BACK_AUX is set for depth camera. It is used to dual-camera devices. Generally, it would not be used.)

MountAngle: 0, 90, 180, 270.

LaneMask & LaneAssign & ComboMode:

```
*LaneMask :
    Mask to mention which lane is enabled.
    LaneMask[0] for DL0.
    LaneMask[1] for CLK.
    LaneMask[2] for DL1.
    LaneMask[3] for DL2.
    LaneMask[4] for DL3
*LaneAssign :
    Number which describes the lane mapping between sensor and PHY.
    LaneAssign[0:3] is sensor lane number connected to data lane 0 of PHY on MSM
    LaneAssign[4:7] is sensor lane number connected to data lane 2 of PHY on MSM
    LaneAssign[8:11] is sensor lane number connected to data lane 3 of PHY on MSM
    LaneAssign[12:15] is sensor lane number connected to data lane 4 of PHY on MSM

    NOTE : Lane 1 is reserved for the clock lane.
        Wiring and setting it to a data lane is prohibited.
ComboMode :
    Flag to enable combo mode.
    This flag is enabled if multiple sensors are using same CSI-PHY receiver
```

```
<CameraConfigurationRoot>
  <CameraModuleConfig>
    <CameraId>0</CameraId>
    <SensorName>s5k3p3</SensorName>
    <ActuatorName>dw9763</ActuatorName>
    <EepromName>dw9763_2d</EepromName>
    <FlashName>pmic</FlashName>
    <ChromatixName>s5k3p3_chromatix</ChromatixName>
    <ModesSupported>1</ModesSupported>
    <Position>BACK</Position>
    <MountAngle>270</MountAngle>
    <CSIInfo>
      <CSIDCore>0</CSIDCore>
      <LaneMask>0x1F</LaneMask>
      <LaneAssign>0x4320</LaneAssign>
      <ComboMode>0</ComboMode>
    </CSIInfo>
    <LensInfo>
      <FocalLength>3.57</FocalLength>
      <FNumber>2.0</FNumber>
      <TotalFocusDistance>1.2</TotalFocusDistance>
      <HorizontalViewAngle>64.7</HorizontalViewAngle>
      <VerticalViewAngle>48.5</VerticalViewAngle>
      <MinFocusDistance>0.1</MinFocusDistance>
    </LensInfo>
  </CameraModuleConfig>
```

2. Add all necessary .so file

- Make entry of the new libraries in the file to include in the build.

Path: *vendor/qcom/proprietary/common/config/device-vendor.mk*

```
MM_CAMERA += s5k3p3_chromatix.xml
MM_CAMERA += libmmcamera_s5k3p3
MM_CAMERA += libchromatix_s5k3p3_default_preview_dw9763
MM_CAMERA += libchromatix_s5k3p3_default_video_dw9763
MM_CAMERA += libchromatix_s5k3p3_hfr_120_dw9763
MM_CAMERA += libchromatix_s5k3p3_hfr_60_dw9763
MM_CAMERA += libchromatix_s5k3p3_hfr_90_dw9763
MM_CAMERA += libchromatix_s5k3p3_zsl_preview_dw9763
MM_CAMERA += libchromatix_s5k3p3_zsl_video_dw9763
MM_CAMERA += libchromatix_s5k3p3_common
MM_CAMERA += libchromatix_s5k3p3_cpp_hfr_120
MM_CAMERA += libchromatix_s5k3p3_cpp_hfr_60
MM_CAMERA += libchromatix_s5k3p3_cpp_hfr_90
MM_CAMERA += libchromatix_s5k3p3_cpp_liveshot
MM_CAMERA += libchromatix_s5k3p3_cpp_preview
MM_CAMERA += libchromatix_s5k3p3_cpp_snapshot
MM_CAMERA += libchromatix_s5k3p3_cpp_video
MM_CAMERA += libchromatix_s5k3p3_hfr_120
MM_CAMERA += libchromatix_s5k3p3_hfr_60
MM_CAMERA += libchromatix_s5k3p3_hfr_90
MM_CAMERA += libchromatix_s5k3p3_preview
MM_CAMERA += libchromatix_s5k3p3_snapshot
MM_CAMERA += libchromatix_s5k3p3_default_video
MM_CAMERA += libchromatix_s5k3p3_postproc
MM_CAMERA += libmmcamera_dw9763_2d_eeprom
```

4.2.4. Summary

- Add sensor driver and chromatix code.
- Configure power supply in kernel and power-on/off sequence.
- Configure the following two .xml files:
  - *vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/configs/msm8953_camera.xml*
  - *vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/configs/s5k3p3_chromatix.xml*
- Add compile file vendor/qcom/proprietary/common/config/device-vendor.mk.

4.3. YUV Sensor Configuration

The above configurations (***Chapter 4.1*** and ***Chapter 4.2***) are based on Bayer sensor. Part of configuration is different when the sensor output type is YUV, and the main differences are listed below:

1. Vendor driver configuration about sensor_output is different.

Reference:
vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/sensor/libs/xxx/xxx_lib.h

```
.sensor_output =
{
  .output_format = SENSOR_YCBCR,
  .connection_mode = SENSOR_MIPI_CSI,
  .raw_output = SENSOR_8_BIT_DIRECT,
  .filter_arrangement = SENSOR_YUYV,
},
```

2. There is no chromatix code, so there is no need to configure *xxx_chromatix.xml*. There is also no need to add ChromatixName in *msm8953_camera.xml*.

5 Add AF Actuator Driver

This chapter provides guidelines to customers who write their own AF actuator driver.

5.1. Updating a Device Tree File

1. In the target's camera .dtsi file, e.g., *msm8909-camera-sensor-mtp.dtsi*, add an entry for the actuator node and assign qcom,actuator-src with actuator node.

Path: *kernel/arch/arm/boot/dts/qcom/msm8909-camera-sensor-mtp.dtsi*

```
actuator0: qcom,actuator@0 {
        cell-index = <0>;
        reg = <0x3>;
        compatible = "qcom,actuator";
        qcom,cci-master = <0>;
        cam_vaf-supply = <&pm8909_l8>;
        qcom,cam-vreg-name = "cam_vaf";
        qcom,cam-vreg-type = <0>;
        qcom,cam-vreg-min-voltage = <2850000>;
        qcom,cam-vreg-max-voltage = <2900000>;
        qcom,cam-vreg-op-mode = <80000>;
    };
```

```
qcom,camera@0 {
    cell-index = <0>;
    compatible = "qcom,camera";
    reg = <0x2>;
    qcom,csiphy-sd-index = <0>;
    qcom,csid-sd-index = <0>;
    qcom,mount-angle = <90>;
    qcom,actuator-src = <&actuator0>;
    qcom,led-flash-src = <&led_flash0>;
    qcom,eeprom-src = <&eeprom0>;
```

2. Please note that the power supply of AF is specified together with the camera sensor and it is the fourth entry in the list of each vreg name, type, min-voltage, max-voltage and op-mode.

```
qcom,camera@0 {
    cell-index = <0>;
    compatible = "qcom,camera";
    reg = <0x2>;
    qcom,csiphy-sd-index = <0>;
    qcom,csid-sd-index = <0>;
    qcom,mount-angle = <90>;
    qcom,actuator-src = <&actuator0>;
/*  qcom,led-flash-src = <&led_flash0>;*/
/*  qcom,eeprom-src = <&eeprom0>;*/
    cam_vdig-supply = <&pm8909_l2>;
    cam_vana-supply = <&pm8909_l17>;
    cam_vio-supply = <&pm8909_l6>;
    cam_vaf-supply = <&pm8909_l8>;
    qcom,cam-vreg-name = "cam_vdig", "cam_vio", "cam_vana",
                         "cam_vaf";
    qcom,cam-vreg-type = <0 1 0 0>;
    qcom,cam-vreg-min-voltage = <1200000 0 2800000 2850000>;
    qcom,cam-vreg-max-voltage = <1200000 0 2850000 2900000>;
    qcom,cam-vreg-op-mode = <200000 0 80000 100000>;
    pinctrl-names = "cam_default", "cam_suspend";
    pinctrl-0 = <&cam_sensor_mclk0_default
            &cam_sensor_rear_default>;
    pinctrl-1 = <&cam_sensor_mclk0_sleep &cam_sensor_rear_sleep>;
    gpios = <&msm_gpio 26 0>,
        <&msm_gpio 35 0>,
        <&msm_gpio 34 0>,
        <&msm_gpio 9 0>,
```

5.2. Add AF Actuator User Space Driver

1. Adding AF actuator files

vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/actuator_libs/<actuator>/
├── Android.mk
├── <actuator>_actuator.c
└── <actuator>_actuator.h

2. Adding AF algorithm tuning files

About SC60, there is no individual chromatix code. It is contained in sensor 3A file.

endor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/chromatix/0309/chromatix_s5k3p3/3A/
Such as: *default_preview/chromatix_s5k3p3_default_preview_dw9763.h*

```
/* Header Info */
{
   0x0309, /* Version */
   "s5k3p3", /* Module Name */
   "dw9763", /* Actuator Name */
   ACT_MAIN_CAM_0, /* Cam Name */
},
```

3. Update msm8953_camera.xml configuration

vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/configs/msm8953_camera.xml

```
<CameraConfigurationRoot>
  <CameraModuleConfig>
    <CameraId>0</CameraId>
    <SensorName>s5k3p3</SensorName>
    <ActuatorName>dw9763</ActuatorName>
    <EepromName>dw9763_2d</EepromName>
```

5.3. Updating the Device Tree

In our camera target .dtsi file, the actuator node needs to be added. And the AF power supply is set together with the sensor's, it need set vreg-name/type/min -voltage/max-voltage/op-mode.

```
actuator0: qcom,actuator@0 {
    cell-index = <0>;
    reg = <0x0>;
    compatible = "qcom,actuator";
    qcom,cci-master = <0>;
    cam_vaf-supply = <&pm8953_l17>;
    qcom,cam-vreg-name = "cam_vaf";
    qcom,cam-vreg-min-voltage = <2850000>;
    qcom,cam-vreg-max-voltage = <2850000>;
    qcom,cam-vreg-op-mode = <80000>;
};
```

```
qcom,camera@0 {
    cell-index = <0>;
    compatible = "qcom,camera";
    reg = <0x0>;
    qcom,csiphy-sd-index = <0>;
    qcom,csid-sd-index = <0>;
    qcom,mount-angle = <270>;
    qcom,led-flash-src = <&led_flash0>;
    qcom,eeprom-src = <&eeprom0>;
    qcom,actuator-src = <&actuator0>;
    cam_vio-supply = <&pm8953_l6>;
    cam_vdig-supply = <&pm8953_l2>;      //not used
    cam_vaf-supply = <&pm8953_l17>;
    cam_vana-supply = <&pm8953_l22>;
    qcom,cam-vreg-name = "cam_vio", "cam_vdig", "cam_vaf",
                         "cam_vana";
    qcom,cam-vreg-min-voltage = <0 1100000 2850000 2800000>;
    qcom,cam-vreg-max-voltage = <0 1100000 2850000 2800000>;
    qcom,cam-vreg-op-mode = <0 105000 100000 80000>;
```

6 Add EEPROM Driver

This chapter provides guidelines to customers who write their own EEPROM driver.

6.1. Updating a Device Tree File

In the target camera .dtsi file, e.g., *msm8953-camera-sensor-mtp.dtsi*, add an entry for EEPROM node and assign qcom,eeprom-src with EEPROM node.

Path: *kernel/msm-3.18/arch/arm/boot/dts/qcom/msm8953-camera-sensor-mtp.dtsi*

```
eeprom0: qcom,eeprom@0 {
    cell-index = <0>;
    compatible = "qcom,eeprom";
    qcom,cci-master = <0>;
    reg = <0xb0>;
    cam_vio-supply = <&pm8953_l6>;
    cam_vdig-supply = <&pm8953_l2>;     //not used
    cam_vaf-supply = <&pm8953_l17>;
    cam_vana-supply = <&pm8953_l22>;
    qcom,cam-vreg-name = "cam_vio", "cam_vdig", "cam_vaf", "cam_vana";
    qcom,cam-vreg-min-voltage = <0 1100000 2850000 2800000>;
    qcom,cam-vreg-max-voltage = <0 1100000 2850000 2800000>;
    qcom,cam-vreg-op-mode = <0 105000 100000 80000>;
    pinctrl-names = "cam_default", "cam_suspend";
    pinctrl-0 = <&cam_sensor_mclk0_default
            &cam_sensor_rear_default
            &cam_sensor_rear_vana>;
    pinctrl-1 = <&cam_sensor_mclk0_sleep &cam_sensor_rear_sleep
            &cam_sensor_rear_vana_sleep>;
    gpios = <&tlmm 26 0>,
        <&tlmm 40 0>,
        <&tlmm 39 0>,
        <&tlmm 3 0>;
```

```
qcom,camera@0 {
    cell-index = <0>;
    compatible = "qcom,camera";
    reg = <0x0>;
    qcom,csiphy-sd-index = <0>;
    qcom,csid-sd-index = <0>;
    qcom,mount-angle = <270>;
    qcom,led-flash-src = <&led_flash0>;
    qcom,eeprom-src = <&eeprom0>;
    qcom,actuator-src = <&actuator0>;
```

6.2. Updating a Sensor Driver File

Considering the *s5k3p3* driver as an example, the eeprom_name field should be updated to *msm8953_camera.xml*.

Path:
vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/configs/msm8953_camera.xml

```
<CameraModuleConfig>
  <CameraId>0</CameraId>
  <SensorName>s5k3p3</SensorName>
  <ActuatorName>dw9763</ActuatorName>
  <EepromName>dw9763_2d</EepromName>
  <FlashName>pmic</FlashName>
  <ChromatixName>s5k3p3_chromatix</ChromatixName>
```

6.3. Adding a EEPROM Driver File

The following *<eeprom>.c* file must be added for a new EEPROM driver.

vendor/qcom/proprietary/mm-camera/mm-camera2/media-controller/modules/sensors/eeprom/libs/<eeprom>/
├── Android.mk
├── <eeprom>_eeprom.c
└── <eeprom>_eeprom.h

Any new *<eeprom>.c* file should have the following function pointers mapped and defined in it. Any of

these functions not defined in that EEPROM driver must be set to NULL.

```
static eeprom_lib_func_t <eeprom>_lib_func_ptr = {
.get_calibration_items = NULL,
.format_calibration_data = NULL,
.do_af_calibration = NULL,
.do_wbc_calibration = NULL,
.do_lsc_calibration = NULL,
.do_dpc_calibration = NULL,
.get_dpc_calibration_info = NULL,
.get_raw_data = NULL,
};
```

7 LED Flash Driver

This chapter provides guidelines to customers who write their own LED Flash driver. We only show the important parts in this chapter.

7.1. Updating a Device Tree File

1. In the target camera .dtsi file, e.g., *msm8953-camera-sensor-mtp.dtsi*, add an entry for led_flash node and assign qcom,led-flash-src with led_flash node.

```
qcom,camera@0 {
    cell-index = <0>;
    compatible = "qcom,camera";
    reg = <0x0>;
    qcom,csiphy-sd-index = <0>;
    qcom,csid-sd-index = <0>;
    qcom,mount-angle = <270>;
    qcom,led-flash-src = <&led_flash0>;
    qcom,eeprom-src = <&eeprom0>;
    qcom,actuator-src = <&actuator0>;
```

2. Depending on the LED Flash hardware, OEMs can decide which type of interface driver to configure. Some LED Flash hardware needs a power supply at input to turn it on/off. For such LED Flash hardware, OEMs can use a PMIC-based LED Flash driver to supply current/power from the PMIC IC. This driver is very simple and just calls PMIC APIs to control the current/power level for different Flash states. Other LED Flash hardware must be programmed with register settings to turn it on/off. For that hardware, OEMs can use either QUP- or I2C-based LED Flash drivers.

Node entry in the device tree file will change based on the type of LED Flash driver (PMIC-based, I2C-based).

For more details and explanation of each field in device tree file, please refer to:
kernel/msm-3.18/Documentation/devicetree/bindings/media/video/msm-camera-flash.txt
kernel/msm-3.18/Documentation/devicetree/bindings/leds/leds-gpio.txt

3. PMIC-based LED Flash driver

PMIC-based LED flash driver is located in *kernel/msm-3.18/arch/arm/boot/dts/qcom/msm-pmixxx.dtsi*, such as *msm-pmi8950.dtsi*. It defines the source of flash, parameters and handle.

```
led_flash0: qcom,camera-flash {
    cell-index = <0>;
    compatible = "qcom,camera-flash";
    qcom,flash-type = <1>;
    qcom,flash-source = <&pmi8950_flash0 &pmi8950_flash1>;
    qcom,torch-source = <&pmi8950_torch0 &pmi8950_torch1>;
    qcom,switch-source = <&pmi8950_switch>;
};
```

```
pmi8950_flash0: qcom,flash_0 {
        label = "flash";
        qcom,led-name = "led:flash_0";
        qcom,default-led-trigger =
                "flash0_trigger";
        qcom,max-current = <1000>;
        qcom,duration = <1280>;
        qcom,id = <0>;
        qcom,current = <625>;
};

pmi8950_flash1: qcom,flash_1 {
        label = "flash";
        qcom,led-name = "led:flash_1";
        qcom,default-led-trigger =
                "flash1_trigger";
        qcom,max-current = <1000>;
        qcom,duration = <1280>;
        qcom,id = <1>;
        qcom,current = <625>;
};

pmi8950_torch0: qcom,torch_0 {
        label = "torch";
        qcom,led-name = "led:torch_0";
        qcom,default-led-trigger =
                "torch0_trigger";
        qcom,max-current = <200>;
        qcom,id = <0>;
        qcom,current = <120>;
};

pmi8950_torch1: qcom,torch_1 {
        label = "torch";
        qcom,led-name = "led:torch_1";
        qcom,default-led-trigger =
                "torch1_trigger";
        qcom,max-current = <200>;
        qcom,id = <1>;
        qcom,current = <120>;
};
```

8 Troubleshooting

8.1. Check Log

1. The correct log

- Probe succeeded

```
[    21.038576] msm_cci_init:1426: hw_version = 0x10020005
[    21.038882] s5k3p3 probe succeeded
[    21.040163] msm_pcm_volume_ctl_get substream runtime not found
```

2. The error log

- If it failed to communicate with the slave device, then it means that is a wrong I2C address or the slave device does not work.

```
MASTER_0 error 0x10000000
msm_cci_i2c_read:955 read_words = 0, exp words = 1
msm_cci_i2c_read_bytes:1038 failed rc -22
msm_camera_cci_i2c_read: line 45 rc = -22
```

- If ID matching is failed and there is no bus error as shown above, then it means that the read ID is different from the configured ID.

```
msm_sensor_match_id: s5k3p3: read id failed
msm_sensor_check_id:1372 match id failed rc -22
s5k3p3 power up failed
```

- If sensor power up failed, then it means that there are some problems in the power up setting. First, we need check the address of I2C, dts, the pin configuration of the vendor driver and the sequence of power.

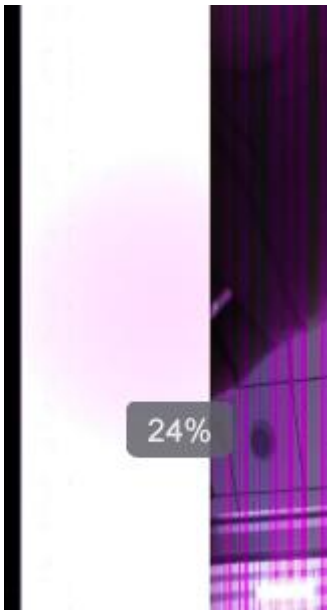
- The following log indicates a failure in getting stream. This is maybe caused by incorrect register-configuration, or problematic MIPI signal and improper lane_cnt in xxx_lib.h

```
Kernel log:
msm_private_ioctl:Notifying subdevs about potential sof freeze
MSM-SENSOR-INIT msm_sensor_init_subdev_ioctl:121 default
```

```
Logcat log:
E/mm-camera( 316): mct_bus_sof_thread_run: SOF freeze; Sending error message
```

If the first frame shows crash and then return, and the log shows ERROR_CRC, ERROR_PHY_DL0_FIFO_OVERFLOW error, please refer to the hardware to find the CRC and DL0 error. Generally, please check settle_cnt value in xxx_lib.h. log as below:

```
msm_csid_irq CSID0_IRQ_STATUS_ADDR = 0x1100033
```



3. Settle_cnt calculate

settle_cnt: Also known as settle count. This value must be configured, based on the sensor's output characteristics, to ensure the sensor's PHY transmitter does not have sync issues with the MSM's PHY receiver.

For 28nm and smaller MSM parts, please use the following formula to calculate settle count:

settle_cnt = T(HS_SETTLE)_avg /T(TIMER_CLK)

- where T(HS_SETTLE)_avg = (T(HS_SETTLE)_min + T(HS_SETTLE)_max) / 2, as indicated by sensor datasheet.
- TIMER_CLK refers to the operating frequency of PHY interface to which camera sensor is connected (for example, CAMSS_PHY0_CSI0PHYTIMER_CLK for PHY0).
- T(TIMER_CLK) is the duration of a clock cycle when operating frequency is equal to TIMER_CLK, and is represented in Nano second unit. For example, T(TIMER_CLK) for TIMER_CLK 200 MHz is (1 * (10^9))/(200 * (10^6)) = 5ns.

9 Appendix A Reference

Table 1: Terms and Abbreviations

Abbreviation	Description
AF	Auto Focus
CSIPHY	Camera Serial Interface Phy Layer
DT	Device Tree
EEPROM	Electrically Erasable Programmable Read-Only Memory
EVB	Evaluation board
GPIO	General Purpose Input Output
I2C	Inter-integrated Circuit
LDO	Low Dropout Regulator
MIPI	Mobile Industry Processor Interface
PMIC	Power Management IC