NXP Semiconductors

User Guide

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i.MX 8M Plus Camera and Display Guide

Contents

Chapter 1
ISP Independent Sensor Interface API

1.1 Overview

This document describes the Application Programming Interface (API) of the i.MX 8M Plus ISP Independent Sensor Interface (ISI) module.

Details of the i.MX 8M Plus ISP Independent Sensor Interface API are described in this document.

- Components such as data types, enumerations, relevant structures, and return codes are described first.
- Then function syntax and description are presented.

The API explained in this document is applicable to BSP release LF5.10.72_2.2.0.

The code is written in C and parameter types follow standard C conventions. This document assumes that the reader understands the fundamentals of C language.

Currently, there are no deprecated functions in this API.

1.1.1 Acronyms and conventions

Table 1. Acronyms

AE	Auto Exposure
AEC	Auto Exposure Control
AF	Auto Focus
AFM	Auto Focus Measurement
AHB	Advance High
AWB	Auto White Balance
AXI	Advanced eXtensible Interface
BPT	Bad Pixel Table
CAC	Chromatic Aberration Correction
CPROC	Color Processing Module
CTRL	Control Logic Module
DPCC	Defect Pixel Cluster Correction
DPF	De
FMF	Focus Measure Function
HVS	Human Visual System
IE	Image Effects Module
ISP	Image Signal Processor
ISR	Interrupt Set/Enable Register
LSC	Lens Shade Correction
MI	Memory Interface

Table continues on the next page...

Table 1. Acronyms (continued)

MIPI	Mobile Industry Processor Interface (MIPI) Alliance Standard for camera serial interface 2 (CSI)
MRZE	Main Resize Module
SIMP	Super Impose Module
SMIA	Standard Mobile Imaging Architecture
SoC	System on Chip
SRZE	Self
VSM	Video Stabilization Measurement
WDR	Wide Dynamic Range
YCbCr	Color space with one luma and two chroma components used for digital encoding

Conventions

- The prefix “0x” indicates a hexadecimal number. For example, 0x32CF.
- The prefix “0b” indicates a binary number. For example, "0b0011.0010.1100.1111".
- Code snippets are given in Consolas or Courier typeset.

1.2 Independent Sensor Interface API Components

This section describes the API declared in the **isi/include** directory. Enumerations and structures are listed alphabetically in this document.

1.2.1 Numeric Data Types

The following common numeric data types are used.

Name	Data type
`uint8_t`	Unsigned 8-bit integer
`int8_t`	Signed 8-bit integer
`uint16_t`	Unsigned 16-bit integer
`int16_t`	Signed 16-bit integer
`uint32_t`	Unsigned 32-bit integer
`int32_t`	Signed 32-bit integer
`uint64_t`	Unsigned 64-bit integer
`int64_t`	Signed 64-bit integer
`float`	Float

1.2.2 RESULT Return Codes

This table specifies the return values for the API functions.

RESULT String Values	Description
`RET_FAILURE`	General failure
`RET_INVALID_PARM`	Invalid parameter
`RET_NOTSUPP`	Feature not supported
`RET_NULL_POINTER`	Callback is a NULL pointer
`RET_OUTOFMEM`	Not enough memory available
`RET_OUTOFRANGE`	A configuration parameter is out of range
`RET_PENDING`	Command pending
`RET_SUCCESS`	Function successful
`RET_WRONG_CONFIG`	Given configuration is invalid
`RET_WRONG_HANDLE`	Invalid instance/HAL handle
`RET_WRONG_STATE`	Instance is in the wrong state to shut down

1.2.3 Enumerations

This section describes the enumeration definitions.

1.2.3.1 IsiBayerPattern_e

Specifies the sensor Bayer pattern mode.

Enumeration Values	Value	Description
`ISI_BAYER_RGGB`	0	RGGB Bayer pattern
`ISI_BAYER_GRBG`	1	GRBG Bayer pattern
`ISI_BAYER_GBRG`	2	GBRG Bayer pattern
`ISI_BAYER_BGGR`	3	BGGR Bayer pattern
`ISI_BAYER_MAX`	4	Maximum number of sensor Bayer pattern components

1.2.3.2 IsiColorComponent_e

Specifies the color components.

Enumeration Values	Value	Description
ISI_COLOR_COMPONENT_RED	0	Red color component
ISI_COLOR_COMPONENT_GREENR	1	GreenR color component
ISI_COLOR_COMPONENT_GREENB	2	GreenB color component
ISI_COLOR_COMPONENT_BLUE	3	Blue color component
ISI_COLOR_COMPONENT_MAX	4	Maximum number of color components.

1.2.3.3 IsiExpoFrmType_e

Specifies the sensor exposure time.

Enumeration Values	Value	Description
ISI_EXPO_FRAME_TYPE_1FRAME	0	1 frame exposure type
ISI_EXPO_FRAME_TYPE_2FRAMES	1	2 frames exposure type
ISI_EXPO_FRAME_TYPE_3FRAMES	2	3 frames exposure type
ISI_EXPO_FRAME_TYPE_4FRAMES	3	4 frames exposure type

1.2.3.4 IsiFocus_e

Specifies the focus position type.

Enumeration Values	Value	Description
ISI_FOCUS_MODE_ABSOLUTE	0	Absolute position type
ISI_FOCUS_MODE_RELATIVE	1	Relative position type
ISI_FOCUS_MODE_MAX	2	Maximum number of focus position types.

1.2.3.5 IsiHdrMode_e

Specifies the sensor HDR mode.

Enumeration Values	Value	Description
ISI_MODE_LINEAR	0	Linear HDR mode
ISI_MODE_HDR_STITCH	1	Stitch HDR mode
ISI_MODE_HDR_NATIVE	2	Native HDR mode
ISI_MODE_HDR_MAX	3	Maximum number of HDR modes.

1.2.3.6 IsiSensorTpgMode_e

Specifies the sensor test pattern mode.

Enumeration Values	Value	Description
ISI_TPG_DISABLE	0	Disable mode
ISI_TPG_MODE_0	1	Mode 0
ISI_TPG_MODE_1	2	Mode 1
ISI_TPG_MODE_2	3	Mode 2
ISI_TPG_MODE_3	4	Mode 3
ISI_TPG_MODE_4	5	Mode 4
ISI_TPG_MODE_5	6	Mode 5
ISI_TPG_MAX	7	Maximum number of sensor test pattern modes

1.2.3.7 IsiStitchingMode_e

Specifies the sensor HDR stitching mode.

Enumeration Values	Value	Description
ISI_STITCHING_DUAL_DCG	0	Dual DCG mode 3x12-bit
ISI_STITCHING_3DOL	1	DOL3 frame 3x12-bit
ISI_STITCHING_LINEBYLINE	2	3x12-bit line by line without waiting
ISI_STITCHING_16BIT_COMPRESS	3	16-bit compressed data + 12-bit RAW
ISI_STITCHING_DUAL_DCG_NOWAIT	4	2x12-bit dual DCG without waiting
ISI_STITCHING_2DOL	5	DOL2 frame or 1 CG+VS sx12-bit RAW
ISI_STITCHING_L_AND_S	6	L+S 2x12-bit RAW
ISI_STITCHING_MAX	7	Maximum number of stitching modes

1.2.4 Structures

This section describes the structure definitions.

IsiCamDrvConfig_t

This structure defines camera sensor driver-specific data.

Structure Members	Type	Description
CameraDriverID	uint32_t	Camera sensor driver ID
*pIsiHalQuerySensor	IsiHalQuerySensor_t	Query sensor mode with HAL handle.
*pfIsiGetSensorIss	IsiGetSensorIss_t	The function pointer to initialize the member IsiSensor in this current structure.
IsiSensor	IsiSensor_t	The structure includes the sensor name and the function pointers to control the sensor in the ISI layer.

IsidualGain_t

This structure defines the sensor gain for dual frame exposure HDR.

Structure Members	Type	Description
`dualSGain`	`uint32_t`	Gain for short exposure frame (fixed point, q10)
`dualGain`	`uint32_t`	Gain for normal exposure frame (fixed point, q10)

IsidualInt_t

This structure defines the sensor integration time for dual frame exposure HDR.

Structure Members	Type	Description
`dualSIntTime`	`uint32_t`	Integration time for short exposure frame in microsecond (fixed point, q10)
`dualIntTime`	`uint32_t`	Integration time for normal exposure frame in microseconds (fixed point, q10)

IsiFocusCalibAttr_t

This structure defines the focus calibration information.

Structure Members	Type	Description
`minPos`	`int32_t`	Minimum position
`maxPos`	`int32_t`	Maximum position
`minStep`	`int32_t`	Minimum step size

IsiFocusPos_t

This structure defines the focus position.

Structure Members	Type	Description
`mode`	`IsiFocus_e`	Focus position mode
`Pos`	`int32_t`	Focus position

IsiLinearGain_t

This structure defines the sensor gain (fixed point, q10) for linear mode.

```
Typedef IsiLinearGain_t to uint32_t
```

IsiLinearInt_t

This structure defines the sensor integration time microsecond (fixed point, q10) for linear mode.

```
Typedef IsiLinearInt_t to uint32_t
```

IsiQuadGain_t

This structure defines the sensor gain for quad-frame exposure HDR.

Structure Members	Type	Description
quadVSGain	uint32_t	Gain for very short exposure frame (fixed point, q10)
quadSGain	uint32_t	Gain for short exposure frame (fixed point, q10)
quadGain	uint32_t	Gain for normal exposure frame (fixed point, q10)
quadLGain	uint32_t	Gain for long exposure frame (fixed point, q10)

IsiQuadInt_t

This structure defines the integration time for quad-frame exposure HDR.

Structure Members	Type	Description
quadVSIntTime	uint32_t	Integration time for very short exposure frame in microseconds (fixed point, q10)
quadSIntSTime	uint32_t	Integration time for short exposure frame in microseconds (fixed point, q10)
quadIntTime	uint32_t	Integration time for normal exposure frame in microseconds (fixed point, q10)
quadLIntTime	uint32_t	Integration time for long exposure frame in microseconds (fixed point, q10)

IsiSensor_t

This structure defines attributes for the sensor.

Structure Members	Type	Description
*pszName	const char	Name of the camera-sensor
*pIsiSensorSetPowerIss	IsiSensorSetPowerIss_t	Set sensor power function
*pIsiCreateSensorIss_t	IsiCreateSensorIss_t	Create a sensor handle
*pIsiReleaseSensorIss	IsiReleaseSensorIss_t	Release sensor handle
*pIsiRegisterReadIss	IsiRegisterReadIss_t	Read sensor register
*pIsiRegisterWriteIss	IsiRegisterWriteIss_t	Write sensor register
*pIsiGetSensorModeIss	IsiGetSensorModeIss_t	Get sensor mode information
*pIsiSetSensorModeIss	IsiSetSensorModeIss_t	Set sensor mode index
*pIsiQuerySensorIss	IsiQuerySensorIss_t	Query support sensor mode
*pIsiGetCapsIss	IsiGetCapsIss_t	Get sensor capabilities
*pIsiSetupSensorIss	IsiSetupSensorIss_t	Set sensor format and initialize the sensor

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Structure Members	Type	Description
`*pIsiGetSensorRevisionIss`	`IsiGetSensorRevisionIss_t`	Get sensor revision ID
`*pIsiCheckSensorConnectionIss`	`IsiCheckSensorConnectionIss_t`	Check the sensor connect status
`*pIsiSensorSetStreamingIss`	`IsiSensorSetStreamingIss_t`	Set streaming
`*pIsiGetAeInfoIss_t`	`IsiGetAeInfoIss_t`	Get AE information
`*pIsiSetHdrRatioIss`	`IsiSetHdrRatioIss_t`	Set HDR ratio
`*pIsiGetIntegrationTimeIss`	`IsiGetIntegrationTimeIss_t`	Get integration time
`*pIsiSetIntegrationTimeIss`	`IsiSetIntegrationTimeIss_t`	Set integration time
`*pIsiGetGainIss`	`IsiGetGainIss_t`	Get current sensor gain
`*pIsiSetGainIss`	`IsiSetGainIss_t`	Set sensor gain
`*pIsiGetSensorFpsIss`	`IsiGetSensorFpsIss_t`	Get current frame rate
`*pIsiSetSensorFpsIss_t`	`IsiSetSensorFpsIss`	Set sensor frame rate
`*pIsiSetSensorAfpsLimitsIss`	`IsiSetSensorAfpsLimitsIss_t`	Get auto FPS limit
`*pIsiGetSensorIspStatusIss`	`IsiGetSensorIspStatusIss_t`	Get ISP status (BLC and WB use sensor WB or ISP WB)
`*pIsiGetAeStartExposureIss`	`IsiGetAeStartExposureIss_t`	Get AE start exposure
`*pIsiSetAeStartExposureIss`	`IsiSetAeStartExposureIss_t`	Set AE start exposure
`*pIsiSensorSetBlcIss`	`IsiSensorSetBlcIss_t`	Set sensor BLC (if sensor BLC is used)
`*pIsiSensorSetWBIss`	`IsiSensorSetWBIss_t`	Set sensor WB (if sensor WB is used)
`*pIsiSensorGetExpandCurveIss`	`IsiSensorGetExpandCurveIss_t`	Get expand curve (if sensor data is compressed)
`*pIsiActivateTestPatternIss_t`	`IsiActivateTestPatternIss`	Set sensor test pattern
`*pIsiFocusSetupIss`	`IsiFocusSetupIss`	Create AF handle
`*pIsiFocusReleaseIss`	`IsiFocusReleaseIss_t`	Release AF handle
`pIsiFocusSetIss_t`	`IsiFocusSetIss_t`	Set focus position
`pIsiFocusGetIss_t`	`IsiFocusGetIss_t`	Get focus position
`pIsiGetFocusCalibrateIss`	`IsiGetFocusCalibrateIss_t`	Get focus calibration information

IsiSensorAeInfo_t

This structure defines the ISI layer AE information.

Structure Members	Type	Description
`oneLineExpTime`	`uint32_t`	Sensor one line exposure time in microsecond (fixed point, q10)

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Structure Members	Type	Description
`maxIntTime`	`IsiSensorIntTime_u`	Maximum integration time in microsecond
`minIntTime`	`IsiSensorIntTime_u`	Minimum integration time in microsecond
`maxAGain`	`IsiSensorGain_u`	Maximum analog gain
`minAGain`	`IsiSensorGain_u`	Minimum analog gain
`maxDGain`	`IsiSensorGain_u`	Maximum digital gain
`minDGain`	`IsiSensorGain_u`	Minimum digital gain
`gainStep`	`uint32_t`	Sensor gain step (fixed point, q10)
`currFps`	`uint32_t`	Sensor current FPS (fixed point, q10)
`maxFps`	`uint32_t`	Sensor maximum FPS (fixed point, q10)
`minFps`	`uint32_t`	Sensor minimum FPS (fixed point, q10)
`minAfps`	`uint32_t`	Sensor minimum Auto FPS (fixed point, q10)

`hdrRatio [ISI_EXPO_FRAME_TYPE_MAX-1]`	`uint32_t`	Sensor HDR ratio (fixed point, q10)
		`q10 ISI_EXPO_PARAS_FIX_FRACBITS`
		`ISI_EXPO_FRAME_TYPE_1FRAME: no ratio`
		`ISI_EXPO_FRAME_TYPE_2FRAMES: hdrRatio[0]= Normal/Short`
		`ISI_EXPO_FRAME_TYPE_3FRAMES: hdrRatio[0]= Long/Normal hdrRatio[1]=Normal/Short`

`intUpdateDlyFrm`	`uint8_t`	Integration update delay frames.
`gainUpdateDlyFrm`	`uint8_t`	Gain update delay frames.

IsiSensorBlc_t

This structure defines the configuration structure used to set the sensor black level.

```
Typedef IsiSensorBlc_t to sensor_blc_t
```

IsiSensorCaps_t

This structure defines the sensor capabilities.

Structure Members	Type	Description
`FieldSelection`	`uint32_t`	Sample fields selection:

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Structure Members	Type	Description
		0x1: sample all fields 0x2: sample only even fields 0x4: sample only odd fields
YCSequence	uint32_t	Output order of YUV data
Conv422	uint32_t	Color subsampling mode
HPol	uint32_t	Horizontal polarity
VPol	uint32_t	Vertical polarity
Edge	uint32_t	Sample edge
supportModeNum	uint32_t	Number of support modes
currentMode	uint32_t	Current mode

IsiSensorContext_t

This structure defines the sensor context.

Structure Members	Type	Description
SensorId	uint8_t	Sensor ID
I2cBusNum	uint8_t	The I2C bus to which the sensor is connected.
SlaveAddress	uint16_t	The I2C slave address to which the sensor is configured.
SensorInitAddr	uint32_t	Sensor initialized address
SensorInitSize	uint16_t	Sensor initialized size
NrOfAddressBytes	uint8_t	Number of address bytes.
NrOfDataBytes	uint8_t	Number of data bytes.
fd	int	/dev/v4l-subdev file description
HalHandle	HalHandle_t	Handle of HAL session to use. HalHandle_t is typedef void *.
*pSensor	IsiSensor_t	Pointer to the sensor device. IsiSensor_t is typedef IsiSensor_s.

IsiSensorExpandCurve_t

This structure defines the configuration structure used to set the sensor expand curve.

```
Typedef IsiSensorExpandCurve_t to sensor_expand_curve_t
```

IsiSensorGain_t

This structure defines the sensor gain.

Structure Members	Type	Description
`expoFrmType`	`IsiExpoFrmType_e`	Sensor exposure frame type
`gain`	`IsiSensorGain_u`	Sensor gain

IsiSensorGain_u

This union defines the sensor gain.

Structure Members	Type	Description
`linearGainParas`	`IsiLinearGain_t`	Linear gain parameters
`dualGainParas`	`IsidualGain_t`	Gain parameters for dual exposure HDR
`triGainParas`	`IsiTriGain_t`	Gain parameters for tri-exposure HDR
`quadGainParas`	`IsiQuadGain_t`	Gain parameters for quad-exposure HDR

IsiSensorInstanceConfig_t

This structure defines the configuration structure used to create a new sensor instance.

Structure Members	Type	Description
`SensorId`	`uint8_t`	Sensor ID
`SensorInitAddr`	`uint32_t`	Sensor initialized address
`SensorInitSize`	`uint16_t`	Sensor initialized size
`HalHandle`	`HalHandle_t`	Handle of HAL session to use
`HalDevID`	`uint32_t`	HAL device ID of this sensor
`I2cBusNum`	`uint8_t`	The I2C bus to which the sensor is connected.
`SlaveAddr`	`uint16_t`	The I2C slave address to which the sensor is configured.
`I2cAfBusNum`	`uint8_t`	The I2C bus to which the AF module is connected.
`SlaveAfAddr`	`uint16_t`	The I2C slave address of which the AF module is configured.
`SensorModeIndex`	`uint32_t`	The current sensor mode index
`*pSensor`	`IsiSensor_t`	The pointer to the sensor driver interface
`hSensor`	`IsiSensorHandle_t`	Sensor handle returned by `IsiCreateSensorIss` `IsiSensorHandle_t` is `typedef void *`.
`szSensorNodeName[32]`	`char`	Sensor node name

IsiSensorIntTime_t

This structure defines the sensor integration time.

Structure Members	Type	Description
`expoFrmType`	`IsiExpoFrmType_e`	Sensor exposure frame type
`IntegrationTime`	`IsiSensorIntTime_u`	Sensor integration time

IsiSensorIntTime_u

This union defines the sensor integration time.

Structure Members	Type	Description
`linearInt`	`IsiLinearGain_t`	Linear integration time
`dualInt`	`IsidualGain_t`	Integration time for dual exposure HDR
`triInt`	`IsiTriGain_t`	Integration time for tri-exposure HDR
`quadInt`	`IsiQuadGain_t`	Integration time for quad-exposure HDR

IsiSensorIspStatus_t

This structure defines the ISP status of sensor.

Structure Members	Type	Description
`useSensorAWB`	`bool_t`	0: use ISP WB 1: use sensor WB
`useSensorBLC`	`bool_t`	0: use ISP BLC 1: use sensor BLC

IsiSensorMipiInfo

This structure defines Sensor-specific information for MIPI.

Structure Members	Type	Description
`ucMipiLanes`	`uint8_t`	Number of MIPI lanes used by the sensor.

IsiSensorMode_t

`Typedef IsiSensorMode_t` to `vvcam_mode_info_t`

IsiSensorModeInfoArray_t

`Typedef IsiSensorModeInfoArray _t` to `vvcam_mode_info_array_t`

IsiSensorWB_t

This structure defines the configuration structure used to set the sensor WB.

`Typedef IsiSensorWB_t_t` to `sensor_white_balance_t`

IsiTriGain_t

This structure defines the sensor gain for tri-frame exposure HDR.

Structure Members	Type	Description
`triSGain`	`uint32_t`	Gain for short exposure frame (fixed point, q10)
`triGain`	`uint32_t`	Gain for normal exposure frame (fixed point, q10)
`triLGain`	`uint32_t`	Gain for long exposure frame (fixed point, q10)

IsiTriInt_t

This structure defines the integration time for tri-frame exposure HDR.

Structure Members	Type	Description
`triSIntTime`	`uint32_t`	Integration time for very short exposure frame in microseconds (fixed point, q10)
`triIntTime`	`uint32_t`	Integration time for normal exposure frame in microseconds (fixed point, q10)
`triLIntTime`	`uint32_t`	Integration time for long exposure frame in microseconds (fixed point, q10)

sensor_blc_t

Structure Members	Type	Description
`red`	`uint32_t`	Red BLC level
`gr`	`uint32_t`	'Gr' BLC level
`gb`	`uint32_t`	'Gb' BLC level
`blue`	`uint32_t`	Blue BLC level

sensor_data_compress_t

Structure Members	Type	Description
`enable`	`uint32_t`	0: sensor data is not compressed 1: sensor data is compressed
`x_bit`	`uint32_t`	If sensor data is compressed, x_bit represents the data bit width before compression.
`y_bit`	`uint32_t`	If sensor data is compressed, y_bit represents the data bit width after compression.

sensor_expand_curve_t

Structure Members	Type	Description
`x_bit`	`uint32_t`	Input bit width of data decompression curve
`y_bit`	`uint32_t`	Output bit width of data decompression curve
`expand_px[64]`	`uint8_t`	Data decompression curve input interval `index.exp`: `1<<expand_px[i] = expand_x_data[i+1] - expand_x_data[i]`
`expand_x_data[65]`	`uint32_t`	65 points of data decompression curve input
`expand_y_data[65]`	`uint32_t`	65 points of data decompression curve output

sensor_hdr_artio_t

Structure Members	Type	Description
`ratio_l_s`	`uint32_t`	Sensor HDR exposure ratio of long exposure to short exposure (fixed point, q10)
`ratio_s_vs`	`uint32_t`	Sensor HDR exposure ratio of short exposure to very short exposure (fixed point, q10)
`accuracy`	`uint32_t`	Sensor HDR accuracy (fixed point, q10)

sensor_mipi_info_s

Structure Members	Type	Description
`mipi_lane`	`uint32_t`	MIPI lane

sensor_test_pattern_t

Structure Members	Type	Description
`enable`	`uint8_t`	Enable/disable sensor test pattern
`pattern`	`uint32_t`	Sensor test pattern

sensor_white_balance_t

Structure Members	Type	Description
`r_gain`	`uint32_t`	White Balance (WB) R gain
`gr_gain`	`uint32_t`	'WB Gr' gain
`gb_gain`	`uint32_t`	'WB Gb' gain
`b_gain`	`uint32_t`	'WB B' gain

vvcam_ae_info_t

Structure Members	Type	Description
`def_frm_len_lines`	`uint32_t`	Sensor default frame length lines (is always set to the sensor default mode VTS)
`curr_frm_len_lines`	`uint32_t`	Current frame length lines
`one_line_exp_time_ns`	`uint32_t`	One line exposure time (in ns) (always = sensor PCLK * HTS)
`max_longintegration_line`	`uint32_t`	Maximum long integration line
`min_longintegration_line`	`uint32_t`	Minimum long integration line
`max_integration_line`	`uint32_t`	Maximum exposure line
`min_integration_line`	`uint32_t`	Minimum exposure line
`max_vsintegration_line`	`uint32_t`	Maximum very short integration time in microseconds
`min_vsintegration_line`	`uint32_t`	Minimum very short integration time in microseconds
`max_long_again`	`uint32_t`	Maximum long analog gain (fixed point, q10)
`min_long_again`	`uint32_t`	Minimum long analog gain (fixed point, q10)
`max_long_dgain`	`uint32_t`	Maximum long digital gain (fixed point, q10)
`min_long_dgain`	`uint32_t`	Minimum long digital gain (fixed point, q10)
`max_again`	`uint32_t`	Maximum analog gain (fixed point, q10)
`min_again`	`uint32_t`	Minimum analog gain (fixed point, q10)
`max_dgain`	`uint32_t`	Maximum digital gain (fixed point, q10)
`min_dgain`	`uint32_t`	Minimum digital gain (fixed point, q10)
`max_short_again`	`uint32_t`	Maximum short analog gain (fixed point, q10)
`min_short_again`	`uint32_t`	Minimum short analog gain (fixed point, q10)
`max_short_dgain`	`uint32_t`	Maximum short digital gain (fixed point, q10)
`min_short_dgain`	`uint32_t`	Minimum short digital gain (fixed point, q10)
`start_exposure`	`uint32_t`	Start exposure (exposure lines*gain (fixed point, q10))
`gain_step`	`uint32_t`	Gain step (fixed point, q10)
`cur_fps`	`uint32_t`	Current frame rate (fixed point, q10)
`max_fps`	`uint32_t`	Maximum FPS (fixed point, q10)
`min_fps`	`uint32_t`	Minimum FPS (fixed point, q10)
`min_afps`	`uint32_t`	Minimum analog FPS (fixed point, q10)
`int_update_delay_frm`	`uint8_t`	Integration update delay frame
`gain_update_delay_frm`	`uint8_t`	Gain update delay frame
`hdr_radio`	`sensor_hdr_artio_s`	HDR radio

vvcam_clk_s

Structure Members	Type	Description
status	uint32_t	CLK enable status
sensor_mclk	unsigned long	Sensor MIPI clock
csi_max_pixel_clk	unsigned long	Sensor maximum pixel clock

vvcam_mode_info_array_t

This structure is an abstraction of vvcam_mode_info.

Structure Members	Type	Description
count	uint32_t	Number of modes supported
modes[VVCAM_SUPPORT_ MAX_MODE_COUNT]	vvcam_mode_info	Structure of sensor features

vvcam_mode_info_t

Structure Members	Type	Description
index	uint32_t	Mode index
width	uint32_t	Image width
height	uint32_t	Image height
hdr_mode	uint32_t	HDR mode
stitching_mode	uint32_t	HDR stitching mode
bit_width	uint32_t	Sensor bit width
data_compress	sensor_data_compress_t	Sensor data is compressed
bayer_pattern	uint32_t	Bayer mode
ae_info	vvcam_ae_info_t	AE information
mipi_info	sensor_mipi_info_s	Sensor MIPI Information
preg_data	void *	Sensor register configuration point
reg_data_count	uint32_t	Sensor register configuration size

vvcam_sccb_array_s

Structure Members	Type	Description
count	uint32_t	Number of SCCB registers
*sccb_data	vvcam_sccb_data_s	SCCB registers data

vvcam_sccb_cfg_s

Structure Members	Type	Description
slave_addr	uint8_t	Registers slave address
addr_byte	uint8_t	Registers address byte
data_byte	uint8_t	Registers data byte

vvcam_sccb_data_s

Structure Members	Type	Description
addr	uint32_t	Address of the register
data	uint32_t	Data of the register

1.3 Independent Sensor Interface Functions

This section provides an overview of the functions for independent sensor interface.

1.3.1 General API Functions

IsiSensorSetPowerIss

Description:

This function controls the sensor power.

Syntax:

```
RESULT IsiSensorSetPowerIss (
bool_t_t        on
);
```

Parameters:

on	Sensor power status

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_FAILURE, RET_NOTSUPP
```

IsiReadRegister

Description:

This function reads the value from the specified register from the image sensor device.

Syntax:

```
RESULT IsiReadRegister (
IsiSensorHandle_t            handle,
const uint32_t            RegAddress,
uint32_t                *pRegValue
);
```

Parameters:

handle	Sensor instance handle.
RegAddress	Register address.
*pRegValue	Register value read from the register.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_FAILURE, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiWriteRegister

Description:

This function writes a given number of bytes to the image sensor device by calling the corresponding sensor function.

Syntax:

```
RESULT IsiWriteRegister (
IsiSensorHandle_t            handle,
const uint32_t             RegAddress,
const uint32_t             RegValue
);
```

Parameters:

handle	Sensor instance handle.
RegAddress	Register address.
RegValue	Register value to write.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_FAILURE, RET_WRONG_HANDLE, RET_NOTSUPP, RET_NULL_POINTER
```

IsiCreateSensorIss

Description:

This function creates a sensor instance.

Syntax:

```
RESULT IsiCreateSensorIss (
IsiSensorInstanceConfig_t  *pConfig
);
```

Parameters:

*pConfig	Pointer to the configuration of the new sensor instance.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER, RET_OUTOFMEM
```

IsiGetSensorModeIss

Description:

This function is used to get the sensor mode info by sensor mode index.

Syntax:

```
RESULT IsiGetSensorModeIss (
IsiSensorHandle_t  *handle,
void    *pmode
);
```

Parameters:

`* handle`	Sensor instance handle.
`*pmode`	Pointer to the `vvcam_mode_info` data structure.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER, RET_OUTOFMEM
```

IsiSetSensorModeIss

Description:

This function gets sensor mode information by sensor mode index.

Syntax:

```
RESULT IsiSetSensorModeIss (
IsiSensorHandle_t        handle,
IsiSensorMode_t         *pmode
);
```

Parameters:

`* handle`	Sensor instance handle.
`*pmode`	Pointer to the `IsiSensorMode_t` data structure.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NOTSUPP
```

IsiQuerySensorIss

Description:

This function is used to query the sensor support modes info.

Syntax:

```
RESULT IsiQuerySensorIss (
IsiSensorHandle_t  *handle,
vvcam_mode_info_array_t *pSensorInfo
);
```

Parameters:

`* handle`	Sensor instance handle.
`* pSensorInfo`	Pointer to the `vvcam_mode_info_array_s` data structure.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER, RET_OUTOFMEM
```

IsiReleaseSensorIss

Description:

This function destroys/releases a sensor instance.

Syntax:

```
RESULT IsiReleaseSensorIss (
IsiSensorHandle_t   handle
);
```

Parameters:

`Handle`	Sensor instance handle.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NOTSUPP
```

IsiGetCapsIss

Description:

This function fills in the correct pointers for the sensor description structure.

Syntax:

```
RESULT IsiGetCapsIss (
IsiSensorHandle_t   handle,
IsiSensorCaps_t   *pIsiSensorCaps
);
```

Parameters:

`handle`	Sensor instance handle.
`*pIsiSensorCaps`	Pointer to the `IsiSensorCaps_t` data structure.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER
```

IsiSetupSensorIss

Description:

This function sets up the image sensor with the specified configuration.

Syntax:

```
RESULT IsiSetupSensorIss (
IsiSensorHandle_t   handle,
IsiSensorConfig_t   *pConfig
);
```

Parameters:

handle	Sensor instance handle.
*pConfig	Pointer to the IsiSensorCaps_t data structure. (typedef IsiSensorCaps_t IsiSensorConfig_t)

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER
```

IsiSensorSetStreamingIss

Description:

This function enables/disables streaming of sensor data, if possible.

Syntax:

```
RESULT IsiSensorSetStreamingIss (
IsiSensorHandle_t   handle,
bool_t     on
);
```

Parameters:

handle	Sensor instance handle.
on	New streaming state. BOOL_TRUE = on; BOOL_FALSE = off

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_WRONG_STATE
```

IsiCheckSensorConnectionIss

Description:

This function checks the connection to the camera sensor, if possible.

Syntax:

```
RESULT IsiCheckSensorConnectionIss (
IsiSensorHandle_t   handle
);
```

Parameters:

handle	Sensor instance handle.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER
```

IsiGetSensorRevisionIss

Description:

This function reads the sensor revision register and returns it.

Syntax:

```
RESULT IsiGetSensorRevisionIss (
IsiSensorHandle_t   handle,
uint32_t    *p_value
);
```

Parameters:

handle	Sensor instance handle.
*p_value	Pointer to the sensor revision register value.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiRegisterWriteIss

Description:

This function writes a given number of bytes to the image sensor device by calling the corresponding sensor function.

Syntax:

```
RESULT IsiRegisterWriteIss (
IsiSensorHandle_t   handle,
const uint32_t   address,
const uint32_t   *p_value
);
```

Parameters:

handle	Sensor instance handle.
address	Register address.
*p_value	Register value to write.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NOTSUPP
```

IsiRegisterReadIss

Description:

This function reads the value from the specified register from the image sensor device.

Syntax:

```
RESULT IsiRegisterReadIss (
IsiSensorHandle_t   handle,
const uint32_t   address,
uint32_t    value
);
```

Parameters:

handle	Sensor instance handle.
address	Register address.
value	Register value read from the register.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

1.3.2 AEC API Functions

IsiGetAeInfoIss

Description:

This function returns the AE basic information.

Syntax:

```
RESULT IsiGetAeInfoIss(
IsiSensorHandle_t            handle,
IsiSensorAeInfo_t            *pAeInfo
);
```

Parameters:

handle	Sensor instance handle.
*pAeInfo	Pointer to the `IsiSensorAeInfo_t` structure.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER, RET_NOTSUPP, RET_WRONG_HANDLE
```

IsiSetHdrRatioIss

Description:

This function sets the HDR ratio.

Syntax:

```
RESULT IsiSetHdrRatioIss  (
IsiSensorHandle_t            handle,
uint8_t                hdrRatioNum ,
uint32_t*                 HdrRatio
);
```

Parameters:

`handle`	Sensor instance handle.
`hdrRatioNum`	HDR ratio count.
`HdrRatio*`	Pointer to the HDR ratio value (fixed point, q10).

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER, RET_NOTSUPP, RET_WRONG_HANDLE
```

IsiGetGainIss

Description:

This function reads gain values from the image sensor module.

Syntax:

```
RESULT IsiGetGainIss (
IsiSensorHandle_t   handle,
float     *pGain
);
```

Parameters:

`handle`	Sensor instance handle.
`*pGain`	Pointer to the gain values.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER
```

IsiSetGainIss

Description:

This function writes gain values to the image sensor module.

Syntax:

```
RESULT IsiSetGainIss (
IsiSensorHandle_t   handle,
float     NewGain,
float     *pSetGain,
float     *hdr_ratio
);
```

Parameters:

handle	Sensor instance handle.
NewGain	Gain to be set.
*pSetGain	Pointer to the gain values.
&hdr_ratio	Pointer to the HDR ratio.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER
```

IsiGetSensorFpsIss

Description:

This function returns the sensor current frame rate.

Syntax:

```
RESULT IsiGetSensorFpsIss (
IsiSensorHandle_t            handle,
uint32_t                 *pFps,
);
```

Parameters:

handle	Sensor instance handle.
*pFps	Pointer to the frame rate (fixed point, q10).

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiSetSensorFpsIss

Description:

This function sets the sensor frame rate.

Syntax:

```
RESULT IsiSetSensorFpsIss (
IsiSensorHandle_t            handle,
uint32_t                 Fps,
);
```

Parameters:

handle	Sensor instance handle.
Fps	Frame rate (fixed point, q10).

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP, RET_FAILURE
```

IsiSetSensorAfpsLimitsIss

Description:

This function set the minimum FPS for auto FPS control.

Syntax:

```
RESULT IsiSetSensorAfpsLimitsIss (
IsiSensorHandle_t           handle,
uint32_t                minAfps
);
```

Parameters:

handle	Sensor instance handle.
minAfps	Minimum FPS (fixed point, q10) for auto FPS.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiGetAeStartExposureIss

Description:

This function returns the AE start exposure (IntegrationTime(μs) x Gain) (fixed point, q10).

Syntax:

```
RESULT IsiSensorGetStartExposure (
IsiSensorHandle_t           handle,
uint64_t                *pExposure
);
```

Parameters:

handle	Sensor instance handle.
*pExposure	Pointer to the AE Start Exposure (IntegrationTime(μs) x Gain); the value is fixed point q10.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiSensorAeSetStartExposure

Description:

This function sets the AE start exposure (IntegrationTime x Gain).

Syntax:

```
RESULT IsiSensorAeSetStartExposure (
IsiSensorHandle_t            handle,
uint64_t                 fExposure
);
```

Parameters:

`handle`	Sensor instance handle.
`fExposure`	The AE Start Exposure (IntegrationTime(μs) x Gain) to set, the value is fixed point q10

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiGetIntegrationTimeIss

Description:

This function gets the current integration time.

Syntax:

```
RESULT IsiGetIntegrationTimeIss  (
IsiSensorHandle_t            handle,
IsiSensorIntTime_t             *pIntegrationTime
);
```

Parameters:

`handle`	Sensor instance handle (such as OV2725).
`*pIntegrationTime`	Pointer to the data structure `IsiSensorIntTime_t`.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiSetIntegrationTimeIss

Description:

This function sets the integration time.

Syntax:

```
RESULT IsiSetIntegrationTimeIss (
IsiSensorHandle_t            handle,
IsiSensorIntTime_t             *pIntegrationTime,
);
```

Parameters:

handle	Sensor instance handle.
*pIntegrationTime	Pointer to the data structure IsiSensorIntTime_t.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_NULL_POINTER, RET_NOTSUPP, RET_WRONG_HANDLE
```

IsiGetSensorFpsIss

Description:

This function is used to get the sensor current frame rate.

Syntax:

```
RESULT IsiGetSensorFpsIss (
IsiSensorHandle_t   handle,
uint32_t     *pFps,
);
```

Parameters:

handle	Sensor instance handle.
*pFps	Pointer to frame rate.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER
```

IsiSetSensorFpsIss

Description:

This function is used to set the sensor frame rate.

Syntax:

```
RESULT IsiSetSensorFpsIss(
IsiSensorHandle_t   handle,
uint32_t     Fps,
);
```

Parameters:

handle	Sensor instance handle.
Fps	frame rate.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER
```

IsiGetIntegrationTimeIncrementIss

Description:

This function returns the smallest possible integration time increment.

Syntax:

```
RESULT IsiGetIntegrationTimeIncrementIss(
IsiSensorHandle_t   handle,
float     *pIncr
);
```

Parameters:

handle	Sensor instance handle.
*pIncr	Pointer to the smallest possible integration time increment.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER
```

1.3.3 AWB API Functions

IsiGetSensorIspStatusIss

Description:

This function gets the sensor ISP status.

Syntax:

```
RESULT IsiGetSensorIspStatusIss (
IsiSensorHandle_t            handle,
IsiSensorIspStatus_t         *pSensorIspStatus
);
```

Parameters:

handle	Sensor instance handle.
*pSensorIspStatus	Pointer to the sensor ISP status structure IsiSensorIspStatus_t.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiSensorSetBlcIss

Description:

This function is used to set the sensor black level.

Syntax:

```
RESULT IsiSensorSetBlcIss(IsiSensorHandle_t handle, sensor_blc_t *pblc);
```

Parameters:

`handle`	Sensor instance handle.
`pblc`	Pointer to the `sensor_blc_t` structure.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER
```

IsiSensorSetWB

Description:

This function used to set the sensor white balance.

Syntax:

```
RESULT IsiSensorSetWB (
IsiSensorHandle_t            handle,
IsiSensorWB_t             *pWb
);
```

Parameters:

`handle`	Sensor instance handle.
`*pWb`	Pointer to the `IsiSensorWB_t data` structure.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

1.3.4 Expand API Functions

IsiSensorGetExpandCurveIss

Description:

This function used to get the sensor expand curve.

Syntax:

```
RESULT IsiSensorGetExpandCurveIss(
IsiSensorHandle_t   handle,
sensor_expand_curve_t  *pexpand_curve
);
```

Parameters:

`handle`	Sensor instance handle.
`pexpand_curve`	Pointer to the sensor_expand_curve_t structure.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER
```

1.3.5 AF API Functions

IsiFocusSetupIss

Description:

This function sets up the focus module.

Syntax:

```
RESULT IsiFocusSetupIss(
IsiSensorHandle_t            handle
);
```

Parameters:

`handle`	Sensor instance handle.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NOTSUPP
```

IsiFocusReleaseIss

Description:

This function releases the focus module.

Syntax:

```
RESULT IsiFocusReleaseIss (
IsiSensorHandle_t            handle,
);
```

Parameters:

`handle`	Sensor instance handle.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiFocusSetIss

Description:

This function sets the focus position.

Syntax:

```
RESULT IsiFocusSetIss (
IsiSensorHandle_t            handle,
IsiFocusPos_t                 *pPos
);
```

Parameters:

`handle`	Sensor instance handle.
`*pPos`	Pointer to the focus position data structure `IsiFocusPos_t`.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NOTSUPP
```

IsiFocusGetIss

Description:

This function gets the focus position.

Syntax:

RESULT **IsiFocusGetIss** (

IsiSensorHandle_t handle,

IsiFocusPos_t *pPos

);

Parameters:

`handle`	Sensor instance handle.
`*pPos`	Pointer to the focus position data structure `IsiFocusPos_t`.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER, RET_NOTSUPP
```

IsiFocusCalibrateIss

Description:

This function gets the focus calibration information.

Syntax:

```
RESULT IsiFocusCalibrateIss (
IsiSensorHandle_t            handle
IsiFoucsCalibAttr_t            *pFocusCalib
);
```

Parameters:

`handle`	Sensor instance handle.
`*pFocusCalib`	Pointer to the focus calibration data structure `IsiFocusCalibAttr_t`.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NOTSUPP
```

1.3.6 Test Pattern API Functions

IsiActivateTestPattern

Description:

This function activates or deactivates the test pattern of the sensor (default pattern: color bar).

Syntax:

```
RESULT IsiActivateTestPattern (
IsiSensorHandle_t            handle,
IsiSensorTpgMode_e            tpgMode
);
```

Parameters:

handle	Sensor instance handle.
tpgMode	TPG mode.

Returns

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_WRONGSTATE, RET_NULL_POINTER, RET_NOTSUPP
```

1.3.7 Miscellaneous API Functions

IsiDumpAllRegisters

Description:

This function dumps all registers to the specified file.

Syntax:

```
RESULT IsiDumpAllRegisters(
IsiSensorHandle_t   handle,
const uint8_t    *filename
);
```

Parameters:

handle	Sensor instance handle.
*filename	File name to dump all registers.

Returns:

```
RESULT Return Code: RET_SUCCESS, RET_WRONG_HANDLE, RET_NULL_POINTER
```

Chapter 2
Camera Sensor Porting Guide

2.1 Overview

This chapter describes the architecture of the i.MX 8M PLUS Image Signal Processing (ISP sensor driver, API functions, and calling process. It also describes the methods to add new APIs and the implementation process for mounting different sensors.

Acronyms and Conventions

3A: Auto Exposure, Auto Focus, Auto White Balance

AE: Auto Exposure

AF: Auto Focus

API: Application Programming Interface

AWB: Automatic White Balance

BLC: Black Level Correction

fps: Frames Per Second

I2C: Inter-Integrated Circuit

IOCTL: Input Output Control

ISI: Independent Sensor Interface

ISP: Image Signal Processing

ISS: Image Sensor Specific

VVCAM: Vivante’s kernel driver integration layer

WB: White Balance

The prefix “0x” or suffix “H” indicates a hexadecimal number —for example, "0x32CF" or "32CFH".

The prefix “0b” indicates a binary number —for example, "0b0011.0010.1100.1111".

Code snippets are given in Consolas typeset.

2.2 ISP Software Architecture

In the ISP framework, the application layer and 3A (Auto Exposure, Auto Focus, Auto White Balance) layer calls the sensor API. It is done using function pointers in the ISS through the ISI layer code. The data stream which is output by the sensor is sent directly to ISP for processing. In the following figure, the gray arrows represent the function calls and the white arrows represent the direction of the output image data of the sensor.

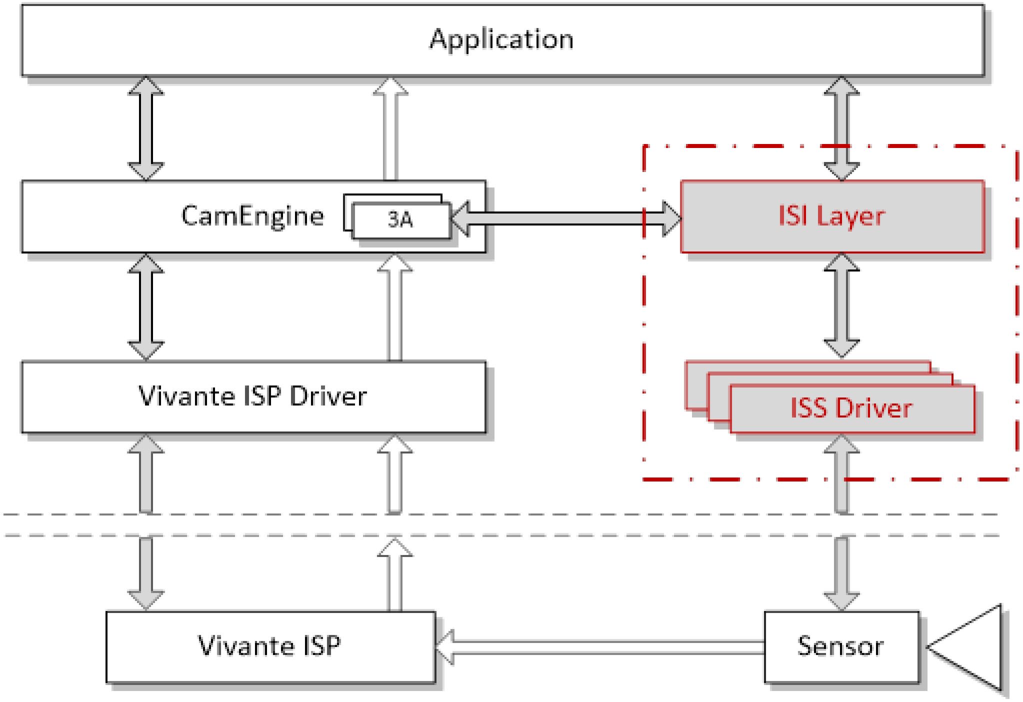

Figure 1. ISP Software Architecture

2.2.1 ISS (Image Sensor Specific) Driver

- Sensor specific implementation
- Sensor specific attributes and behavior from:
  - — Sensor data sheet
  - — Calibration data

2.2.2 ISP Sensor Module Block Diagrams

The i.MX 8M Plus ISP sensor module is organized as shown in the following figures.

1. **Sensor Module in Linux Kernel**: I2C is called in the kernel to read and write the sensor register as shown in Figure 2 below.

- **ISI Layer**: includes the interface to call the corresponding sensor functions, function pointers to mount different sensors, and the structure composed of these function pointers.
  - — **ISS**: uses function pointers so that the ISP driver code can use different sensors independently without modifying the code of other modules.
  - — **Sensor API**: includes sensor power-on, initialization, reading and writing sensor registers, configuring sensor resolution, exposure parameters, obtaining current sensor configuration parameters and other functions.
- **VVCAM**: i.MX 8M Plus ISP kernel driver integration layer which includes ISP, MIPI, camera sensor, and I^{2}C kernel driver.
  - — **Sensor Driver**: performs sensor API operations on sensor hardware.
  - — **I^{2}C:** Read-Write Sensor Register. When writing a register, its value must be a 32-bit value. There is no restriction on reading a register.
  - — **Kernel Working Mode:** VVCAM has two types of working modes in the kernel:

1. V4L2 **Mode**: kernel driver that acts as a part of V4L2 kernel driver, register device name, and operations as a V4L2 subdevice style. This mode is compatible with the V4L2 sensor device format.

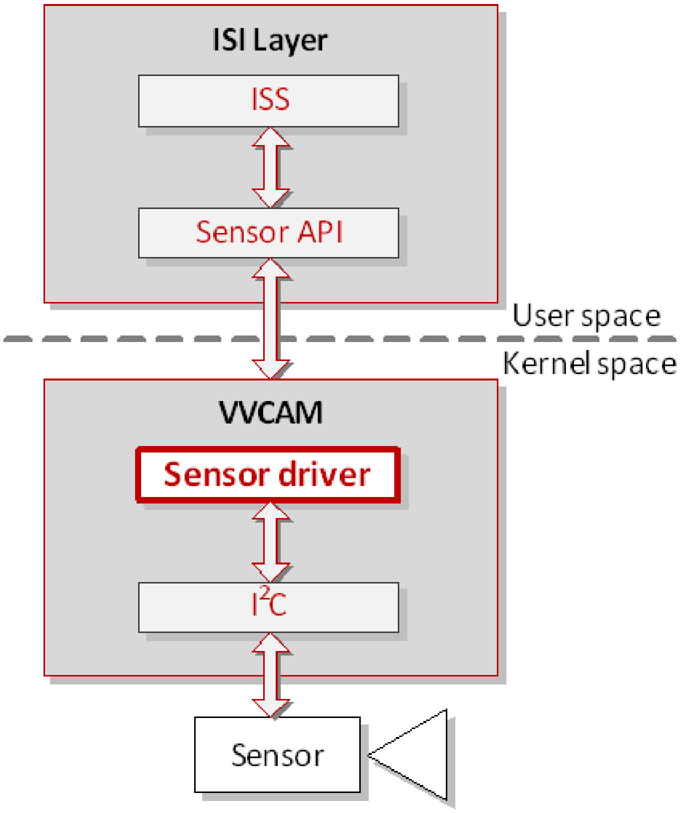

Figure 2. Sensor Module in Linux Kernel

2.3 ISP Independent Sensor Interface (ISI) API reference

For additional information on the ISI API, see ISP Independent Sensor Interface API. Structures and functions are provided here for convenience.

2.3.1 ISI Structures

2.3.1.1 IsiCamDrvConfig_s

This structure defines camera sensor driver-specific data.

Structure Members	Type	Description
`CameraDriverID`	`uint32_t`	Camera sensor driver ID
`*pIsiHalQuerySensor`	`IsiHalQuerySensor_t`	Query sensor mode with HAL handle.

Table continues on the next page...

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Structure Members	Type	Description
`*pfIsiGetSensorIss`	`IsiGetSensorIss_t`	The function pointer to initialize the member IsiSensor in current structure.
`IsiSensor`	`IsiSensor_t`	The structure includes the sensor name and the function pointers to control the sensor in the ISI layer.

2.3.1.2 IsiSensor_t

This structure defines the configuration structure used to create a sensor instance. For data structure definition details, see ISP Independent Sensor Interface API.

Structure Members	Type	Description
`*pszName`	const char	Name of the camera-sensor
`pIsiSensorSetPowerIss`	`IsiSensorSetPowerIss_t`	Set sensor power function
`pIsiCreateSensorIss_t`	`IsiCreateSensorIss_t`	Create sensor handle
`pIsiReleaseSensorIss`	`IsiReleaseSensorIss_t`	Release sensor handle
`pIsiRegisterReadIss`	`IsiRegisterReadIss_t`	Read sensor reg
`pIsiRegisterWriteIss`	`IsiRegisterWriteIss_t`	Write sensor reg
`pIsiGetSensorModeIss`	`IsiGetSensorModeIss_t`	Get sensor mode info
`pIsiSetSensorModeIss`	`IsiSetSensorModeIss_t`	Set sensor mode index
`pIsiQuerySensorIss`	`IsiQuerySensorIss_t`	Query support sensor mode
`pIsiGetCapsIss`	`IsiGetCapsIss_t`	Get sensor caps ability
`pIsiSetupSensorIss`	`IsiSetupSensorIss_t`	Set sensor format and initialize sensor
`pIsiGetSensorRevisionIss`	`IsiGetSensorRevisionIss_t`	Get sensor revision id
`pIsiCheckSensorConnectionIss`	`IsiCheckSensorConnectionIss_t`	Check sensor connect status
`pIsiSensorSetStreamingIss`	`IsiSensorSetStreamingIss_t`	Set streaming
`pIsiGetAeInfoIss_t`	`IsiGetAeInfoIss_t`	Get AE information
`pIsiSetHdrRatioIss`	`IsiSetHdrRatioIss_t`	Set HDR ratio
`pIsiGetIntegrationTimeIss`	`IsiGetIntegrationTimeIss_t`	Get integration time
`pIsiSetIntegrationTimeIss`	`IsiSetIntegrationTimeIss_t`	Set integration time
`pIsiGetGainIss`	`IsiGetGainIss_t`	Get Current sensor gain
`pIsiSetGainIss`	`IsiSetGainIss_t`	Set sensor gain
`pIsiGetSensorFpsIss`	`IsiGetSensorFpsIss_t`	Get current frame rate
`pIsiSetSensorFpsIss_t`	`IsiSetSensorFpsIss`	Set sensor frame rate
`pIsiSetSensorAfpsLimitsIss`	`IsiSetSensorAfpsLimitsIss_t`	Get auto FPS limit

Table continues on the next page...

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Structure Members	Type	Description
`pIsiGetSensorIspStatusIss`	`IsiGetSensorIspStatusIss_t`	Get ISP status (BLC and WB use sensor WB or ISP WB)
`pIsiGetAeStartExposureIss`	`IsiGetAeStartExposureIss_t`	Get AE start exposure
`pIsiSetAeStartExposureIss`	`IsiSetAeStartExposureIss_t`	Set AE start exposure
`pIsiSensorSetBlcIss`	`IsiSensorSetBlcIss_t`	Set sensor BLC (if using sensor BLC)
`pIsiSensorSetWBIss`	`IsiSensorSetWBIss_t`	Set sensor WB (if using sensor Wb)
`pIsiSensorGetExpandCurveIss`	`IsiSensorGetExpandCurveIss_t`	Get expand curve (if sensor data is compressed)
`pIsiActivateTestPatternIss_t`	`IsiActivateTestPatternIss`	Set sensor test pattern
`pIsiFocusSetupIss`	`IsiFocusSetupIss`	Create AF handle
`pIsiFocusReleaseIss`	`IsiFocusReleaseIss_t`	Release AF handle
`pIsiFocusSetIss_t`	`IsiFocusSetIss_t`	Set focus position
`pIsiFocusGetIss_t`	`IsiFocusGetIss`	Get focus position
`pIsiGetFocusCalibrateIss`	`IsiGetFocusCalibrateIss`	Get focus calibration information

2.3.1.3 IsiSensorInstanceConfig_s

This structure defines the configuration structure used to create a sensor instance.

Structure Members	Type	Description
`SensorId`	`uint8_t`	Sensor ID
`SensorInitAddr`	`uint32_t`	Sensor initialized address
`SensorInitSize`	`uint16_t`	Sensor initialized size
`HalHandle`	`HalHandle_t`	Handle of HAL session to use
`HalDevID`	`uint32_t`	HAL device ID of this sensor
`I2cAfBusNum`	`uint8_t`	The I2C bus of focus module
`SlaveAfAddr`	`uint16_t`	The I2C slave address of focus module
`SensorModeIndex`	`uint32_t`	Sensor mode index
`szSensorNodeName[32]`	`char`	Sensor node name
`I2cBusNum`	`uint8_t`	The I2C bus of sensor
`SlaveAddr`	`uint16_t`	The I2C slave address of sensor
`*pSensor`	IsiSensor_t	The pointer to the sensor driver interface
`hSensor`	`IsiSensorHandle_t`	Sensor handle returned by IsiCreateSensorIss

2.3.2 ISI Functions

The following ISI API uses the function pointers defined in the IsiSensor_s data structure to call the corresponding sensor functions defined in the Sensor API Reference section.

Table 2. ISI functions

ISI API	Function Description
`IsiSensorSetPowerIss(…)`	Power-up/power-down the sensor
`IsiReadRegister(…)`	Read sensor register value
`IsiWriteRegister (…)`	Write sensor register value
`IsiCreateSensorIss (…)`	Create a sensor instance and assign resources to sensor
`IsiReleaseSensorIss (…)`	Release sensor a sensor instance
`IsiGetSensorModeIss (…)`	Get sensor mode info
`IsiSetSensorModeIss (…)`	Set sensor mode index
`IsiQuerySensorIss (…)`	Query support sensor mode
`IsiGetCapsIss (…)`	Get sensor caps ability
`IsiSetupSensorIss(…)`	Set sensor format and int sensor
`IsiCheckSensorConnectionIss (…)`	Check sensor connect status
`IsiGetSensorRevisionIss (…)`	Get sensor ID
`IsiSensorSetStreamingIss (…)`	Set sensor streaming status
`IsiGetAeInfoIss (…)`	Get AE information
`IsiSetHdrRatioIss (…)`	Set HDR ratio
`IsiGetIntegrationTimeIss (…)`	Get exposure time in microseconds (fixed point q10)
`IsiSetIntegrationTimeIss (…)`	Set exposure time in microseconds (fixed point q10)
`IsiGetGainIss (…)`	Get sensor gain (fixed point q10)
`IsiSetGainIss (…)`	Set sensor gain (fixed point q10)
`IsiGetSensorFpsIss (…)`	Get sensor frame rate (fixed point q10)
`IsiSetSensorFpsIss (…)`	Set sensor frame rate (fixed point q10)
`IsiSetSensorAfpsLimitsIss (…)`	Set auto FPS limits (fixed point q10)
`IsiGetSensorIspStatusIss (…)`	Get sensor module (BLC, WB) status
`IsiGetAeStartExposureIss (…)`	Get AE start exposure (exposure time us* gain) (fixed point q10)
`IsiSetAeStartExposureIss (…)`	Set AE start exposure (exposure time us* gain) (fixed point q10)
`IsiSensorSetBlc (…)`	Set sensor BLC
`IsiSensorSetWB (…)`	Set sensor WB
`IsiSensorGetExpandCurve (…)`	Get sensor expand curve

Table continues on the next page...

Table 2. ISI functions (continued)

ISI API	Function Description
`IsiActivateTestPattern (…)`	Set sensor test pattern mode
`IsiFocusSetupIss (…)`	AF module setup
`IsiFocusReleaseIss (…)`	AF module release
`IsiFocusSetIss (…)`	Set focus position
`IsiFocusGetIss (…)`	Get focus position
`IsiFocusCalibrateIss (…)`	Get focus calibration information
`IsiDumpAllRegisters (…)`	Reserved

2.3.3 Sensor API Reference

This section describes the API defined in `units/isi/drv/<sensor>/source/<sensor>.c`, where *<sensor>* is the name of the sensor (for example, OV2775). You can refer to the APIs in the following table to define your own API for the sensor which you are using. The upper application layer can use the structure of IsiCamDrvConfig_t to call the following functions.

Table 3. Sensor API reference

Sensor API	Description
SENSOR STRUCTURES	
IsiCamDrvConfig_t	Provide a structure for upper layer to access function pointer
SENSOR FUNCTIONS	
`<sensor>_IsiSensorSetPowerIss(…)`	Power-up/power-down the sensor
`<sensor>_IsiReadRegister(…)`	Read sensor register value
`<sensor>_IsiWriteRegister (…)`	Write sensor register value
`<sensor>_IsiCreateSensorIss (…)`	Create a sensor instance and assign resources to sensor
`<sensor>_IsiReleaseSensorIss (…)`	Release a sensor instance
`<sensor>_IsiGetSensorModeIss (…)`	Get sensor mode information
`<sensor>_IsiSetSensorModeIss (…)`	Set sensor mode index
`<sensor>_IsiQuerySensorIss (…)`	Query support sensor mode
`<sensor>_IsiGetCapsIss (…)`	Get sensor caps ability
`<sensor>_IsiSetupSensorIss(…)`	Set sensor format and int sensor
`<sensor>_IsiCheckSensorConnectionIss (…)`	Check sensor connect status
`<sensor>_IsiGetSensorRevisionIss (…)`	Get sensor ID
`<sensor>_IsiSensorSetStreamingIss (…)`	Set sensor streaming status
`<sensor>_IsiGetAeInfoIss (…)`	Get AE info
`<sensor>_IsiSetHdrRatioIss (…)`	Set HDR ratio
`<sensor>_IsiGetIntegrationTimeIss (…)`	Get exposure time us (fixed point q10)

Table continues on the next page...

Table 3. Sensor API reference (continued)

Sensor API	Description
`<sensor>_IsiSetIntegrationTimeIss (…)`	Set exposure time us (fixed point q10)
`<sensor>_IsiGetGainIss (…)`	Get sensor gain (fixed point q10)
`<sensor>_IsiSetGainIss (…)`	Set sensor gain (fixed point q10)
`<sensor>_IsiGetSensorFpsIss (…)`	Get sensor frame rate (fixed point q10)
`<sensor>_IsiSetSensorFpsIss (…)`	Set sensor frame rate (fixed point q10)
`<sensor>_IsiSetSensorAfpsLimitsIss (…)`	Set auto FPS limits (fixed point q10)
`<sensor>_IsiGetSensorIspStatusIss (…)`	Get sensor module (BLC, WB) status
`<sensor>_IsiGetAeStartExposureIss (…)`	Get AE start exposure (exposure time us* gain) (fixed point q10)
`<sensor>_IsiSetAeStartExposureIss (…)`	Set AE start exposure (exposure time us* gain) (fixed point q10)
`<sensor>_IsiSensorSetBlc (…)`	Set sensor BLC
`<sensor>_IsiSensorSetWB (…)`	Set sensor WB
`<sensor>_IsiSensorGetExpandCurve (…)`	Get sensor expand curve
`<sensor>_IsiActivateTestPattern (…)`	Set sensor test pattern mode
`<sensor>_IsiFocusSetupIss (…)`	AF module setup
`<sensor>_IsiFocusReleaseIss (…)`	AF module release
`<sensor>_IsiFocusSetIss (…)`	Set focus position
`<sensor>_IsiFocusGetIss (…)`	Get focus position
`<sensor>_IsiFocusCalibrateIss (…)`	Get focus calibration information

2.3.4 ISS Sensor Driver User Space Flow

Function Pointers

In the ISS (Image Sensor Specific) driver, we define function pointers of the same type as the sensor API. We also integrate these function pointers into the IsiSensor_s data structure. The driver then integrates the IsiSensor_s structure, camera driver ID, and IsiGetSensorIss_t function pointers into the IsiCamDrvConfig_s data structure. In the function corresponding to the IsiGetSensorIss_t function pointer, the driver mounts the sensor API to the function pointer defined in the ISS layer. The application layer can operate the sensor API by accessing this data structure. Refer to the Define the Camera Driver Configuration Data Structure section for additional information.

Sensor Defines

There are #defines for the sensor which are unique to each sensor. These #defines must be set according to the requirements of the application. An example of a custom set of #defines for a sensor is given in the Set the Sensor Macro section.

Sensor Exposure Function

The exposure function in the sensor is also different for each sensor. To modify the exposure function, refer to the data sheet of the sensor for specific implementation methods. An example of a customized exposure function is given in the Write Customized Exposure Parameters section. The IsiGetSensorIss_t function pointer interface defined in ISI corresponds to the sensor API. Each ISI API calls the corresponding sensor API through the function pointer.

The application layer obtains the address of the function pointer with the IsiCamDrvConfig_t data structure through the SensorOps::driverChange() function.

```
SensorOps::driverChange(std::string driverFileName, std::string calibFileName) {
    …..
    DCT_ASSERT(!pCamDrvConfig->pfIsiGetSensorIss(&pCamDrvConfig->IsiSensor));
pSensor = &pCamDrvConfig->IsiSensor;
```

At the same time, the application layer passes this address down to ISS so that ISS can access different sensors.

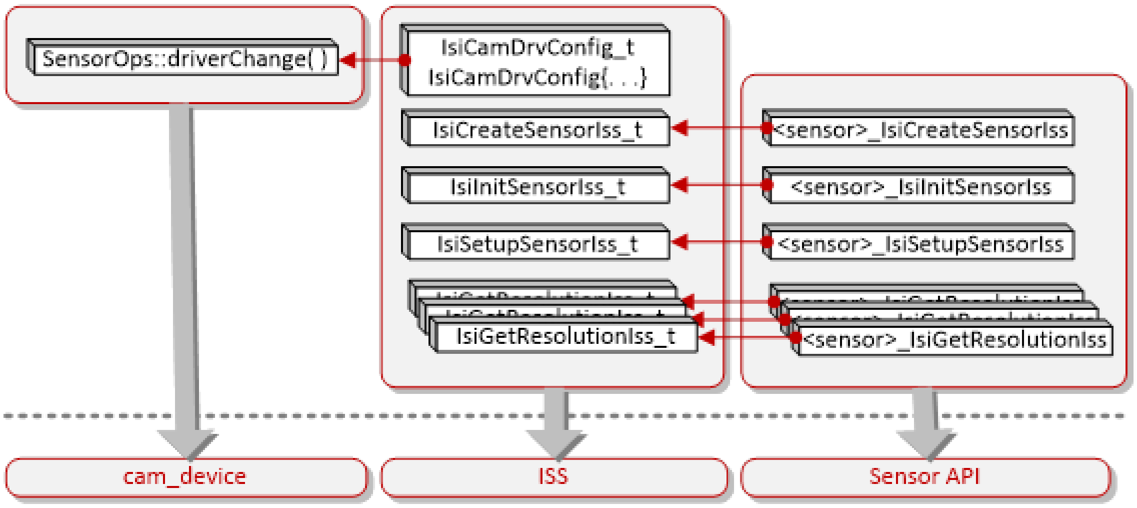

Figure 3. User Space Flow

2.4 IOCTL Introduction

The interface in the user space cannot operate the functions directly in the kernel space. Commands and parameters of the operations are called with the use of IOCTL commands.

2.4.1 IOCTL Commands

The corresponding operations for IOCTL commands in the kernel space are shown in the following table.

Table 4. IOCTL Commands (Native Mode)

IOCTL	IOCTL Operation
VVSENSORIOC_RESET	Reset sensor
VVSENSORIOC_S_POWER	Set sensor power
VVSENSORIOC_G_POWER	Get sensor power
VVSENSORIOC_S_CLK	Set sensor clock
VVSENSORIOC_G_CLK	Get sensor clock
VVSENSORIOC_QUERY	Query support sensor mode

Table continues on the next page...

Table 4. IOCTL Commands (Native Mode) (continued)

IOCTL	IOCTL Operation
`VVSENSORIOC_S_SENSOR_MODE`	Set sensor mode
`VVSENSORIOC_G_SENSOR_MODE`	Get sensor mode
`VVSENSORIOC_READ_REG`	Read register
`VVSENSORIOC_WRITE_REG`	Write register
`VVSENSORIOC_READ_ARRAY`	Read register array
`VVSENSORIOC_WRITE_ARRAY`	Write register array
`VVSENSORIOC_G_NAME`	Get sensor name
`VVSENSORIOC_G_RESERVE_ID`	Get reserve sensor ID
`VVSENSORIOC_G_CHIP_ID`	Get chip ID
`VVSENSORIOC_S_INIT`	Set sensor initialization
`VVSENSORIOC_S_STREAM`	Set sensor stream
`VVSENSORIOC_S_LONG_EXP`	Set long exposure
`VVSENSORIOC_S_EXP`	Set exposure
`VVSENSORIOC_S_VSEXP`	Set very short exposure
`VVSENSORIOC_S_LONG_GAIN`	Set long gain
`VVSENSORIOC_S_GAIN`	Set gain
`VVSENSORIOC_S_VSGAIN`	Set very short gain
`VVSENSORIOC_S_FPS`	Set frame rate
`VVSENSORIOC_G_FPS`	Get frame rate
`VVSENSORIOC_S_HDR_RADIO`	Set HDR ratio
`VVSENSORIOC_S_WB`	Set white balance
`VVSENSORIOC_S_BLC`	Set black level correction
`VVSENSORIOC_G_EXPAND_CURVE`	Get expand curve
`VVSENSORIOC_S_TEST_PATTERN`	Set test pattern

2.4.2 IOCTL Call Flow

The IOCTL supports both Native Mode and V4L2 Mode as described below.

2.4.2.1 Native Mode

The figure below shows the IOCTL call flow in Native mode. For more details, refer to the VVCAM Flow in Native Mode section.

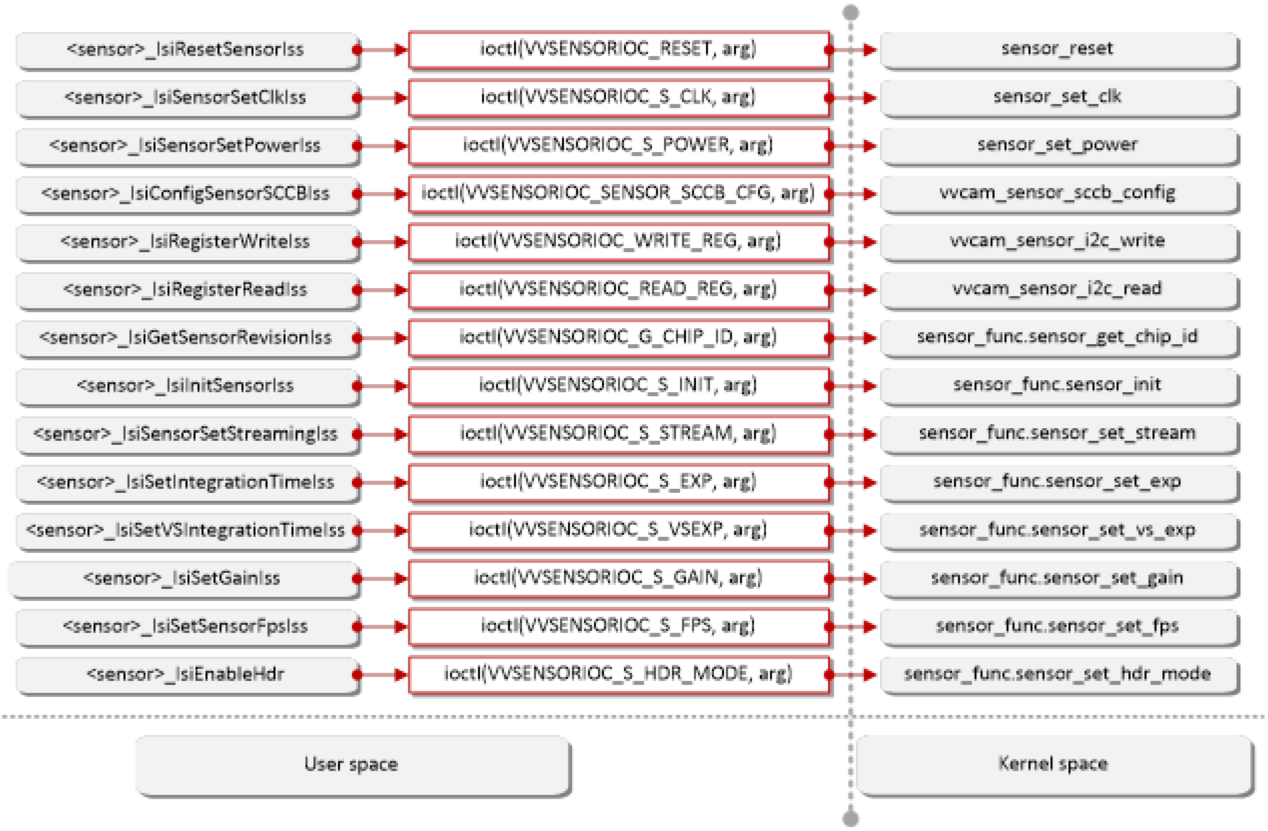
<sensor>_IsiResetSensorIss
ioctl(VVSENSORIOC_RESET, arg)
sensor_reset
<sensor>_IsiSensorSetClkIss
ioctl(VVSENSORIOC_S_CLK, arg)
sensor_set_clk
<sensor>_IsiSensorSetPowerIss
ioctl(VVSENSORIOC_S_POWER, arg)
sensor_set_power
<sensor>_IsiConfigSensorSCCBIss
ioctl(VVSENSORIOC_SENSOR_SCCB_CFG, arg)
vvcam_sensor_sccb_config
<sensor>_IsiRegisterWriteIss
ioctl(VVSENSORIOC_WRITE_REG, arg)
vvcam_sensor_i2c_write
<sensor>_IsiRegisterReadIss
ioctl(VVSENSORIOC_READ_REG, arg)
vvcam_sensor_i2c_read
<sensor>_IsiGetSensorRevisionIss
ioctl(VVSENSORIOC_G_CHIP_ID, arg)
sensor_func.sensor_get_chip_id
<sensor>_IsiInitSensorIss
ioctl(VVSENSORIOC_S_INIT, arg)
sensor_func.sensor_init
<sensor>_IsiSensorSetStreamingIss
ioctl(VVSENSORIOC_S_STREAM, arg)
sensor_func.sensor_set_stream
<sensor>_IsiSetIntegrationTimeIss
ioctl(VVSENSORIOC_S_EXP, arg)
sensor_func.sensor_set_exp
<sensor>_IsiSetVSIntegrationTimeIss
ioctl(VVSENSORIOC_S_VSEXP, arg)
sensor_func.sensor_set_vs_exp
<sensor>_IsiSetGainIss
ioctl(VVSENSORIOC_S_GAIN, arg)
sensor_func.sensor_set_gain
<sensor>_IsiSetSensorFpsIss
ioctl(VVSENSORIOC_S_FPS, arg)
sensor_func.sensor_set_fps
<sensor>_IsiEnableHdr
ioctl(VVSENSORIOC_S_HDR_MODE, arg)
sensor_func.sensor_set_hdr_mode
User space
Kernel space

Figure 4. IOCTL Call Flow in Native Mode

2.4.2.2 V4L2 Mode

The figure below shows the IOCTL call flow in V4L2 mode. For more details, refer to the VVCAM Flow in V4L2 Mode section.

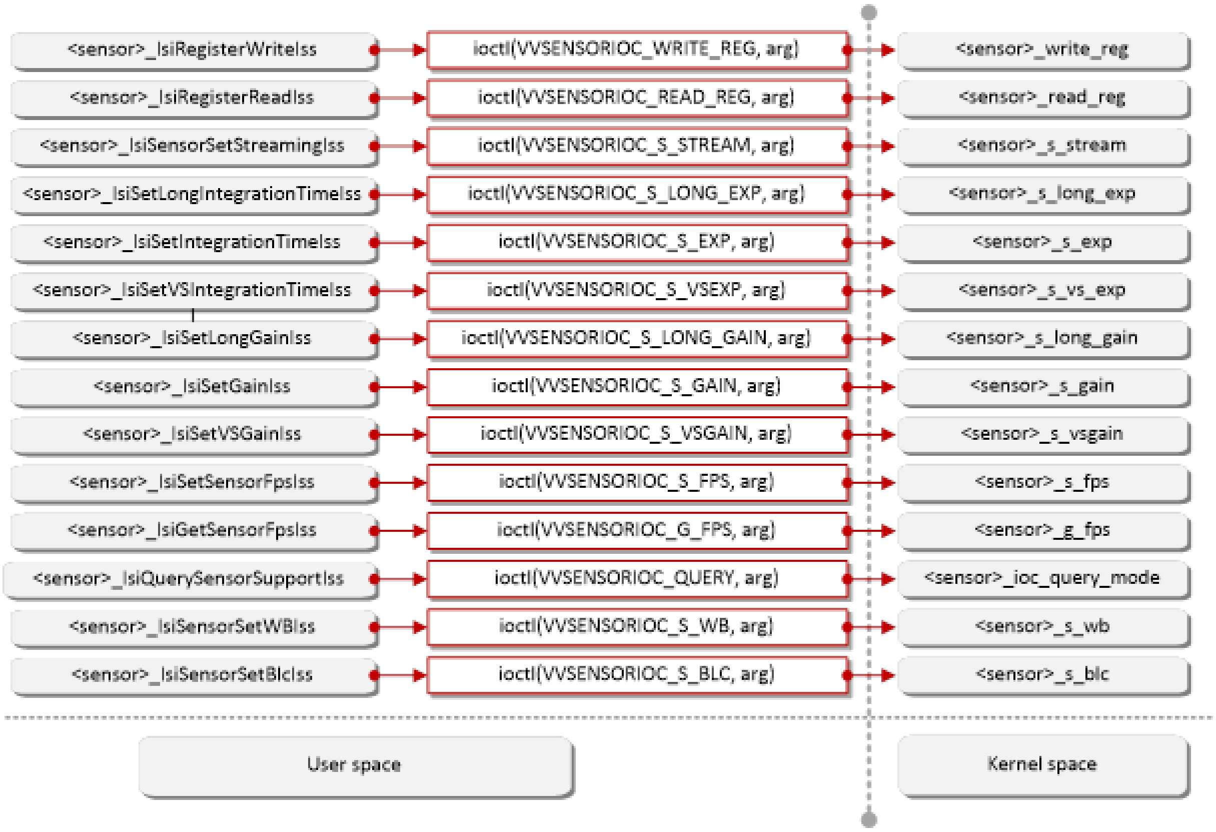
<sensor>_IsiRegisterWriteIss
ioctl(VVSENSORIOC_WRITE_REG, arg)
<sensor>_write_reg
<sensor>_IsiRegisterReadIss
ioctl(VVSENSORIOC_READ_REG, arg)
<sensor>_read_reg
<sensor>_IsiSensorSetStreamingIss
ioctl(VVSENSORIOC_S_STREAM, arg)
<sensor>_s_stream
<sensor>_IsiSetLongIntegrationTimeIss
ioctl(VVSENSORIOC_S_LONG_EXP, arg)
<sensor>_s_long_exp
<sensor>_IsiSetIntegrationTimeIss
ioctl(VVSENSORIOC_S_EXP, arg)
<sensor>_s_exp
<sensor>_IsiSetVSIntegrationTimeIss
ioctl(VVSENSORIOC_S_VSEXP, arg)
<sensor>_s_vs_exp
<sensor>_IsiSetLongGainIss
ioctl(VVSENSORIOC_S_LONG_GAIN, arg)
<sensor>_s_long_gain
<sensor>_IsiSetGainIss
ioctl(VVSENSORIOC_S_GAIN, arg)
<sensor>_s_gain
<sensor>_IsiSetVSGainIss
ioctl(VVSENSORIOC_S_VSGAIN, arg)
<sensor>_s_vsgain
<sensor>_IsiSetSensorFpsIss
ioctl(VVSENSORIOC_S_FPS, arg)
<sensor>_s_fps
<sensor>_IsiGetSensorFpsIss
ioctl(VVSENSORIOC_G_FPS, arg)
<sensor>_g_fps
<sensor>_IsiQuerySensorSupportIss
ioctl(VVSENSORIOC_QUERY, arg)
<sensor>_ioc_query_mode
<sensor>_IsiSensorSetWBIss
ioctl(VVSENSORIOC_S_WB, arg)
<sensor>_s_wb
<sensor>_IsiSensorSetBlcIss
ioctl(VVSENSORIOC_S_BLC, arg)
<sensor>_s_blc
User space
Kernel space

Figure 5. IOCTL Call Flow in V4L2 Mode

2.5 VVCam API Reference

This section describes the API declared in **vvcam/common/vvsensor.h**.

2.5.1 Sensor Driver Enumerations

2.5.1.1 SENSOR_BAYER_PATTERN_E

enum Members	Description
`BAYER_RGGB`	Bayer RGGB pattern mode
`BAYER_GRBG`	Bayer GRBG pattern mode
`BAYER_GBRG`	Bayer GBRB pattern mode
`BAYER_BGGR`	Bayer BGGR pattern mode
`BAYER_MAX`	Number of Bayer pattern modes

2.5.1.2 sensor_hdr_mode_e

enum Members	Description
SENSOR_MODE_LINEAR	Linear mode.
SENSOR_MODE_HDR_STITCH	ISP HDR mode.
SENSOR_MODE_HDR_NATIVE	Before ISP processes the different exposure images, they are combined in the sensor.

2.5.1.3 sensor_stitching_mode_e

enum Members	Description
SENSOR_STITCHING_DUAL_DCG	Dual DCG mode 3x12-bit
SENSOR_STITCHING_3DOL	3 DOL frame 3x12-bit
SENSOR_STITCHING_LINEBYLINE	3x12-bit line by line without waiting
SENSOR_STITCHING_16BIT_COMPRESS	16-bit compressed data + 12-bit RAW
SENSOR_STITCHING_DUAL_DCG_NOWAIT	2x12-bit dual DCG without waiting
SENSOR_STITCHING_2DOL	DOL2 frame or 1 CG+VS sx12-bit RAW
SENSOR_STITCHING_L_AND_S	L+S 2x12-bit RAW
SENSOR_STITCHING_MAX	Number of sensor stitching modes

2.5.2 Sensor Driver Structures

2.5.2.1 sensor_blc_t

Structure Members	Type	Description
red	uint32_t	Red Black Level Correction (BLC) level
gr	uint32_t	Gr BLC level
gb	uint32_t	Gb BLC level
blue	uint32_t	Blue BLC level

2.5.2.2 sensor_data_compress_t

Structure Members	Type	Description
`enable`	`uint32_t`	0: sensor data is not compressed 1: sensor data is compressed
`x_bit`	`uint32_t`	If sensor data is compressed, x_bit represents the data bit width before compression.
`y_bit`	`uint32_t`	If sensor data is compressed, y_bit represents the data bit width after compression.

2.5.2.3 sensor_expand_curve_t

Structure Members	Type	Description
`x_bit`	`uint32_t`	Input bit width of data decompression curve
`y_bit`	`uint32_t`	Output bit width of data decompression curve
`expand_px[64]`	`uint8_t`	Data decompression curve input interval `index.exp: 1<<expand_px[i] = expand_x_data[i+1] - expand_x_data[i]`
`expand_x_data[65]`	`uint32_t`	65 points of data decompression curve input
`expand_y_data[65]`	`uint32_t`	65 points of data decompression curve output

2.5.2.4 sensor_hdr_artio_t

Structure Members	Type	Description
`ratio_l_s`	`uint32_t`	Sensor HDR exposure ratio of long exposure to short exposure (fixed point, q10)
`ratio_s_vs`	`uint32_t`	Sensor HDR exposure ratio of short exposure to very short exposure (fixed point, q10)
`accuracy`	`uint32_t`	Sensor HDR accuracy (fixed point, q10)

2.5.2.5 sensor_mipi_info

Structure Members	Type	Description
`mipi_lane`	`uint32_t`	MIPI lane

2.5.2.6 sensor_test_pattern_t

Structure Members	Type	Description
`enable`	`uint8_t`	Enable/disable sensor test pattern
`pattern`	`uint32_t`	Sensor test pattern

2.5.2.7 sensor_white_balance_t

Structure Members	Type	Description
`r_gain`	`uint32_t`	White Balance (WB) R gain
`gr_gain`	`uint32_t`	WB Gr gain
`gb_gain`	`uint32_t`	WB Gb gain
`b_gain`	`uint32_t`	WB B gain

2.5.2.8 vvcam_ae_info_t

Structure Members	Type	Description
`def_frm_len_lines`	`uint32_t`	Sensor default Frame length lines (always in sensor default mode VTS)
`curr_frm_len_lines`	`uint32_t`	Current Frame length lines
`one_line_exp_time_ns`	`uint32_t`	One line exposure time (in ns) (always = sensor PCLK * HTS)
`max_longintegration_line`	`uint32_t`	Maximum long integration line
`min_longintegration_line`	`uint32_t`	Minimum long integration line
`max_integration_line`	`uint32_t`	Maximum exposure line
`min_integration_line`	`uint32_t`	Minimum exposure line
`max_vsintegration_line`	`uint32_t`	Maximum very short integration time in micro second
`min_vsintegration_line`	`uint32_t`	Minimum very short integration time in micro second
`max_long_again`	`uint32_t`	Maximum long analog gain (fixed point, q10)
`min_long_again`	`uint32_t`	Minimum long analog gain (fixed point, q10)
`max_long_dgain`	`uint32_t`	Maximum long digital gain (fixed point, q10)
`min_long_dgain`	`uint32_t`	Minimum long digital gain (fixed point, q10)
`max_again`	`uint32_t`	Maximum analog gain (fixed point, q10)
`min_again`	`uint32_t`	Minimum analog gain (fixed point, q10)

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Structure Members	Type	Description
max_dgain	uint32_t	Maximum digital gain (fixed point, q10)
min_dgain	uint32_t	Minimum digital gain (fixed point, q10)
max_short_again	uint32_t	Maximum short analog gain (fixed point, q10)
min_short_again	uint32_t	Minimum short analog gain (fixed point, q10)
max_short_dgain	uint32_t	Maximum short digital gain (fixed point, q10)
min_short_dgain	uint32_t	Minimum short digital gain (fixed point, q10)
start_exposure	uint32_t	Start exposure (exposure lines*gain (fixed point, q10))
gain_step	uint32_t	Gain step (fixed point, q10)
cur_fps	uint32_t	Current frame rate (fixed point, q10)
max_fps	uint32_t	Maximum FPS (fixed point, q10)
min_fps	uint32_t	Minimum FPS (fixed point, q10)
min_afps	uint32_t	Minimum analog FPS (fixed point, q10)
int_update_delay_frm	uint8_t	Integration update delay frame
gain_update_delay_frm	uint8_t	Gain update delay frame
hdr_radio	sensor_hdr_artio_t	HDR radio

2.5.2.9 vvcam_clk_s

Structure Members	Type	Description
status	uint32_t	CLK enable status
sensor_mclk	unsigned long	Sensor MIPI clock
csi_max_pixel_clk	unsigned long	Sensor maximum pixel clock

2.5.2.10 vvcam_mode_info_array_t

This structure is an abstraction of `vvcam_mode_info`.

Structure Members	Type	Description
count	uint32_t	Number of modes supported
modes[VVCAM_SUPPORT_MAX_MODE_COUNT]	struct vvcam_mode_info	Structure of sensor feature

2.5.2.11 vvcam_mode_info_t

Structure Members	Type	Description
index	uint32_t	Mode index
width	uint32_t	Image width
height	uint32_t	Image height
hdr_mode	uint32_t	HDR mode
stitching_mode	uint32_t	HDR stitching mode
bit_width	uint32_t	Sensor bit width
data_compress	sensor_data_compress_t	Sensor data is compressed
bayer_pattern	uint32_t	Bayer mode
ae_info	vvcam_ae_info_t	AE information
mipi_info	sensor_mipi_info	Sensor MIPI Information
preg_data	void *	Sensor register configuration point
reg_data_count	uint32_t	Sensor register configuration size

2.5.2.12 vvcam_sccb_array_s

Structure Members	Type	Description
count	uint32_t	Number of SCCB registers
*sccb_data	vvcam_sccb_data_s	SCCB registers data

2.5.2.13 vvcam_sccb_cfg_s

Structure Members	Type	Description
slave_addr	uint8_t	Registers slave address
addr_byte	uint8_t	Registers address byte
data_byte	uint8_t	Registers data byte

2.5.2.14 vvcam_sccb_data_s

Structure Members	Type	Description
addr	uint32_t	Registers address
data	uint32_t	Registers data

2.5.2.15 vvcam_sensor_function_s

This structure defines function pointers corresponding to functions in the sensor driver. This structure is only used in Native mode.

Structure Members	Type	Description
`sensor_name[16]`	`uint8_t`	Sensor name
`reserve_id`	`uint32_t`	Correct sensor ID which is stored in sensor driver
`sensor_clk`	`uint32_t`	Input clock Frequency (Hz) of sensor
`mipi_info`	sensor_mipi_info_s	Feature of MIPI CSI interface: lanes and data width

`sensor_get_chip_id`	`int32_t (*sensor_get_chip_id)`
	`(void *ctx, uint32_t *chip_id)`
		Function pointer to get ID from sensor register

`sensor_init`	`int32_t (*sensor_init) (void *ctx, vvcam_mode_info_t *pmode)`	Function pointer to initialize the vvcam_mode_info data structure
`sensor_set_stream`	`int32_t (*sensor_set_stream) (void *ctx, uint32_t status)`	Function pointer to open/close sensor data stream
`sensor_set_exp`	`int32_t (*sensor_set_exp) (void *ctx, uint32_t exp_line)`	Function pointer to set the exposure time in line unit
`sensor_set_vs_exp`	`int32_t (*sensor_set_vs_exp) (void *ctx, uint32_t exp_line)`	Function pointer to set the exposure time of the very short exposure frame in HDR mode
`sensor_set_gain`	`int32_t (*sensor_set_gain) (void *ctx, uint32_t gain)`	Function pointer to set the gain in multiples rather than dB
`sensor_set_vs_gain`	`int32_t (*sensor_set_vs_gain) (void *ctx, uint32_t gain)`	Function pointer to set the gain of the very short exposure frame in multiples rather than dB
`sensor_set_fps`	`int32_t (*sensor_set_fps) (void *ctx, uint32_t fps)`	Function pointer to set the frame rate of sensor in FPS(frames per second)
`sensor_set_resolution`	`int32_t (*sensor_set_resolution) (void *ctx, uint32_t width, uint32_t height)`	Function pointer to set the resolution of sensor
`sensor_set_hdr_mode`	`int32_t (*sensor_set_hdr_mode) (void *ctx, uint32_t hdr_mode)`	Function pointer to select the HDR mode of sensor
`sensor_query`	`int32_t (*sensor_query) (void *ctx, vvcam_mode_info_array_t *pmode_info_arry)`	Function pointer to query sensor information

2.5.3 Sensor Driver API

V4l2 Sensor Driver API is declared in file `<sensor>_mipi_v3.c`, where `<sensor>` is the name of the sensor (for example, OV2775).

Table 5. Sensor Native Driver API

API Name	Description
extern struct vvcam_sensor_function_s <sensor>_function	Mounts sensor driver to function pointer
sensor_query(…)	Query sensor information
sensor_write_reg(…)	Write register
sensor_read_reg(…)	Read register
sensor_write_reg_arry(…)	Write register array
sensor_get_chip_id(…)	Get the chip ID in sensor
sensor_init(…)	Initialize the vvcam_mode_info data structure
sensor_set_stream (…)	Turn the flow of the sensor on or off
sensor_set_exp(…)	Write the exposure time of 3A decomposition exposure parameter to the register of the sensor
sensor_set_vs_exp(…)	Write the exposure time of 3A decomposition exposure parameter for a very short exposure frame to the the register of the sensor
sensor_calc_gain(…)	Calculate sensor gain
sensor_set_gain(…)	Set the gain in multiples rather than dB
sensor_set_vs_gain (…)	Set the gain of the very short exposure frame in multiples rather than dB
sensor_set_fps(…)	Set the frame rate of sensor
sensor_set_resolution(…)	Set the resolution of sensor
sensor_set_hdr_mode(…)	Select the HDR mode of sensor

Table 6. Sensor V4l2 Driver API

API Name	Description
<sensor>_g_clk(…)	Get sensor clock
<sensor>_power_on(…)	Power on sensor
<sensor>_power_off(…)	Power off sensor
<sensor>_s_power(…)	Set sensor power
<sensor>_write_reg(…)	Write data to the specified register
<sensor>_read_reg(…)	Read data from the specified register
<sensor>_write_reg_arry(…)	Write register array
<sensor>_query_capability(…)	Query sensor capability
<sensor>_query_supports(…)	Query sensor support modes
<sensor>_get_sensor_id(…)	Get sensor ID

Table continues on the next page...

Table 6. Sensor V4l2 Driver API (continued)

API Name	Description
<sensor>_get_reserve_id(…)	Get reserve sensor ID
<sensor>_get_sensor_mode(…)	Get sensor mode
<sensor>_set_sensor_mode(…)	Set sensor mode
<sensor>_set_lexp(…)	Write the exposure time of 3A decomposition exposure parameter for a long exposure frame to the the register of the sensor
<sensor>_set_exp(…)	Write the exposure time of 3A decomposition exposure parameter to the the register of the sensor
<sensor>_set_vsexp(…)	Write the exposure time of 3A decomposition exposure parameter for a very short exposure frame to the the register of the sensor
<sensor>_set_lgain(…)	Set the gain of the long exposure frame in multiples rather than dB
<sensor>_set_gain(…)	Set the gain in multiples rather than dB
<sensor>_set_vsgain(…)	Set the gain of the very short exposure frame in multiples rather than dB
<sensor>_set_fps(…)	Set sensor FPS
<sensor>_get_fps(…)	Get sensor FPS
<sensor>_set_test_pattern(…)	Set test pattern
<sensor>_set_ratio(…)	Set sensor HDR ratio
<sensor>_set_blc(…)	Set sensor sub BLC
<sensor>_set_wb(…)	Set white balance
<sensor>_get_expand_curve(…)	Get sensor expand curve
<sensor>_get_format_code(…)	Get format code
<sensor>_s_stream(…)	Start or stop the sensor
<sensor>_enum_mbus_code(…)	Enum MBUS code
<sensor>_set_fmt(…)	Set sensor format
<sensor>_get_fmt(…)	Get sensor format
<sensor>_priv_ioctl(…)	Private I/O control
<sensor>_link_setup(…)	Link setup
<sensor>_regulator_enable(…)	Enable regulator
<sensor>_regulator_disable(…)	Disable regulator
<sensor>_set_clk_rate(…)	Set clock rate
<sensor>_reset(…)	Reset sensor
<sensor>_retrieve_capture_properties(…)	Retrieve capture properties

Table continues on the next page...

Table 6. Sensor V4l2 Driver API (continued)

API Name	Description
<sensor>_probe(…)	Probe sensor
<sensor>_remove(…)	Remove sensor
<sensor>_suspend(…)	Suspend sensor
<sensor>_resume(…)	Resume sensor

2.6 Camera Sensor Driver in Native Mode

2.6.1 VVCAM Flow in Native Mode

Read through this section carefully before porting the new sensor driver in Native Mode. If you have any problems during the sensor porting process, refer to the existing sensor driver of the platform in your source code release.

To add a function interface, refer to the following sections:

- ISI API Reference
- ISS Sensor Driver User Space Flow
- Sensor API Reference
- VVCAM Flow in Native Mode (this section)

Both hub and sensor kernel driver must add corresponding interfaces and calls. Different sensors in the sensor data sheet have different conversion methods to convert the exposure parameters. The exposure parameters are passed down from the 3A modules to the values written in the registers. This must be taken care of while porting the sensor. The sensor data must be accurately defined.

To port the camera sensor, the following steps must be taken as described in the following sections:

1. Define sensor attributes and create the sensor instance.
2. Define the camera driver configuration data structure.
3. Set the sensor macro.
4. Write customized exposure parameters.
5. Modify the sensor driver.
6. Set up HDR.
7. Define MIPI lanes.
8. Configure the MIPI Sensor.

2.6.1.1 Sensor Driver Software Architecture in Native Mode

The software architecture of the sensor driver in Native Mode is shown in the figure below.

Function pointers corresponding to the sensor driver function are defined in the header file `vvcam/native/sensor/sensor_common.hand` are integrated into the vvcam_sensor_function_s data structure. The function ports corresponding to the sensor driver function are also defined in the `<sensor>_driver.c` file. These interfaces are used to call the sensor driver. The corresponding functions are in the `<sensor>_priv_ioctl()` function.

Function `<sensor>_priv_ioctl()` is used to receive the commands and parameters passed down by user space through `ioctl()`. It calls the corresponding functions in `<sensor>_driver.c` according to the commands. After the `<sensor>_priv_ioctl()` is called, the hardware to operate the sensor is realized.

The hardware interface is defined in the sensor driver. These interfaces read and write the hardware registers through I2C to realize the functions to be completed by the sensor API. At the same time, these interfaces are attached to the function pointer in the `vvcam_sensor_function_s data` structure.

The VVCAM driver specifies the `vvcam_sensor_function_s` data structure in `vvcam/native/sensor/Makefile`. The sensor driver then copies the data structure variables of the `vvcam_sensor_function_s` to the member variables of the `vvcam_sensor_dev` data structure.

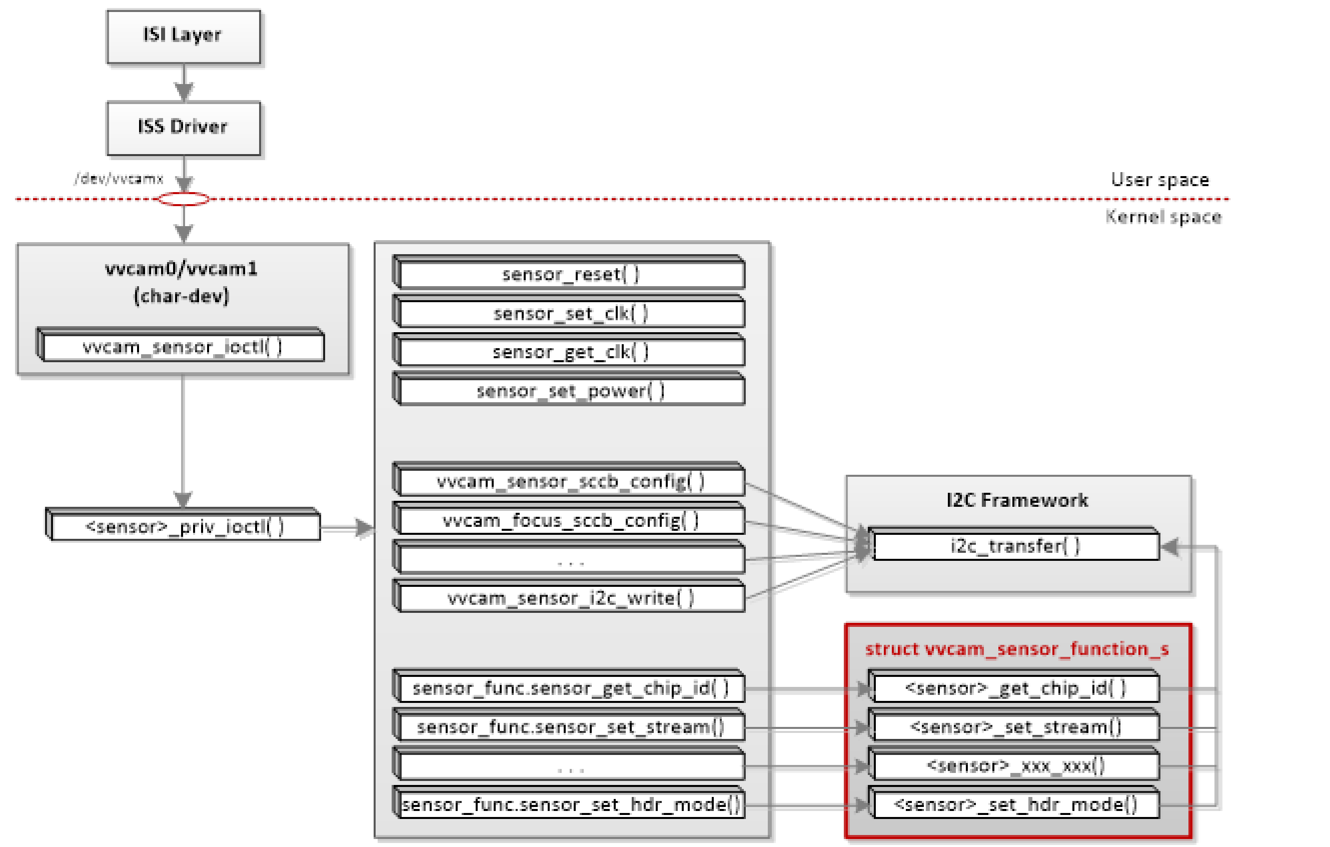


Figure 6. VVCAM Flow in Native Mode

2.6.2 Camera Sensor Porting Setup in Native Mode

2.6.2.1 Define Sensor Attributes and Create Sensor Instance

1. Define the sensor attributes in the IsiSensor_s data structure.
2. Define the IsiSensorInstanceConfig_t configuration structure that is used to create a sensor instance.
3. To create a sensor instance, call the `IsiCreateSensorIss()` function.

2.6.2.2 Define the Camera Driver Configuration Data Structure

Define the IsiCamDrvConfig_s data structure. Data members defined in this data structure include the sensor ID (CameraDriverID) and the function pointer to the IsiSensor data structure. Using the address of the `IsiCamDrvConfig_s` structure, the driver can then access the sensor API attached to the function pointer.

2.6.2.3 Set the Sensor Macro

Sensor macros must be modified to match the sensor attributes in the source file corresponding to the sensor as described below.

An example of a set of sensor macros is given below in file: `units/isi/drv/<sensor>/source/<sensor>.c`.

```
#define SENSOR_SLAVE_ADDR       0x36
#define SENSOR_MIN_GAIN_STEP   (1.0f/16.0f)
#define SENSOR_MAX_GAIN_AEC    (32.0f)
#define SENSOR_VS_MAX_INTEGRATION_TIME (0.0018)
#define SENSOR_VTS_NUM         0x4705
#define SENSOR_HTS_NUM         0x1130
#define SENSOR_PIX_CLOCK       (37.125f)
```

2.6.2.4 Write Customized Exposure Parameters

Since the exposure function in the sensor is unique for each sensor, a customized calculation of exposure parameters must be written. Refer to the data sheet of the sensor for specific implementation values.

Here, we present an example of a customized calculation for the exposure parameters for sensor OV2775.

```
RESULT OV2775_IsiSetGainIss( IsiSensorHandle_t handle,
                             float NewGain,
                             float *pSetGain,
                             float *hdr_ratio
                           )
{
    if( NewGain < 3.0 )
    {
        dGainLcg = 0x02;
        againLcg = 0x00;
    }
    else if( NewGain < 4.375 && NewGain >= 3.0)
    {
        dGainLcg = NewGain / 2.0;
        againLcg = 0x01;
    }
    else if( NewGain < 8.750 && NewGain >= 4.375)
    {
        dGainLcg = NewGain / 4.0;
        againLcg = 0x02;
    }
    else
    {
       dGainLcg = NewGain / 8.0;
       againLcg = 0x03;
    }
}
```

2.6.2.5 Modify the Sensor Driver in Native Mode

To specify a camera sensor, the sensor driver must be modified. The vvcam_sensor_function_s data structure is defined in file `vvcam/native/sensor/<sensor_vendor>_<sensor>/<sensor>.c`. This data structure has data members as variables that store the address of a function in the sensor driver. Later it can be called through that function pointer.

The sensor driver mounts the function to the corresponding function pointer in the structure variable of the `vvcam_sensor_function_s` data structure.

For example:

```
struct vvcam_sensor_function_s ov2775_function = { .sensor_name =
"ov2775", .reserve_id = 0x2770, .sensor_clk = SENSOR_CLK, .mipi_info.mipi_lane =
4, .sensor_get_chip_id = sensor_get_chip_id, .sensor_init = sensor_init, .sensor_set_stream
= sensor_set_stream, .sensor_set_exp = sensor_set_exp, .sensor_set_vs_exp =
sensor_set_vs_exp, .sensor_set_gain = sensor_set_gain, .sensor_set_vs_gain =
sensor_set_vs_gain, .sensor_set_fps = sensor_set_fps, .sensor_set_resolution =
sensor_set_resolution, .sensor_set_hdr_mode = sensor_set_hdr_mode, .sensor_query = sensor_query };
```

In file `vvcam/native/sensor/sensor_ioctl.c`, the driver uses the `SENSR0_FUNCTION` and `SENSR1_FUNCTION` macros to get the `vvcam_sensor_function_s` data structure. The VVCAM operates different sensor drivers by accessing their pointer variables to achieve this.

For example:

```
if (dev->device_idx == 0) { . . . memcpy(&(dev->sensor_func), &(SENSR0_FUNCTION), sizeof(struct
vvcam_sensor_function_s)); } else { . . . memcpy(&(dev->sensor_func), &(SENSR1_FUNCTION),
sizeof(struct vvcam_sensor_function_s)); }
```

NOTE

Developers should add their own sensor into makefile `vvcam/native/sensor/Makefile` as shown in the example below.

```
ifeq ($(SENSR0_TYPE), ov2775)
  $(TARGET)-objs += ./omnivision_ov2775/ov2775_driver.o
  $(TARGET)-objs += ./omnivision_ov2775/ov2775_mipi4lane_1080p_30fps_linear.o
  EXTRA_CFLAGS += -I$(PWD)/omnivision_ov2775
  EXTRA_CFLAGS += -DSENSR0_FUNCTION=ov2775_function
endif

ifeq ($(SENSR1_TYPE), ov2775)
  EXTRA_CFLAGS += -DSENSR1_FUNCTION=ov2775_function
endif
```

2.6.2.6 Set Up HDR

To set up HDR:

- Enable the HDR function of the ISP. Define `ISP_HDR_STITCH` in the ISP configuration file.
- Enable the HDR of the sensor by calling `<sensor>_IsiEnableHdr(IsiSensorHandle_t handle, const bool_t enable).`

For example, in the ISP configuration file:

`vim units/mkrel/ISP8000xxxx_Vxxxx/product_cfg_ISP8000xxxx_Vxxxx.cmake`

where: `ISP8000xxxx_Vxxxx` is the version number of the ISP you are using.

```
add_definitions(-DISP_HDR_STITCH)
```

2.6.2.7 Define MIPI Lanes

In the sensor driver, set `SENSOR_MIPI_LANES` for the MIPI Lane used by the sensor.

For example, in the OV2775 sensor driver file `/isi/drv/OV2775/source/OV2775.c`, modify the MipiLanes data member in the `OV2775_IsiGetCapsIss()` function as shown:

```
pIsiSensorCaps->MipiLanes    = ISI_MIPI_4LANES; // change to ISI_MIPI_2LANES
```

2.6.2.8 Configure the MIPI Sensor

When the MIPI driver starts, it reads the configuration of the current sensor driver MIPI and configures the MIPI according to this configuration.

2.7 Camera Sensor Driver in V4L2 Mode

2.7.1 VVCAM Flow in V4L2 Mode

Read through this section carefully before porting the new sensor driver in V4L2 Mode. If you have any problems during the sensor porting process, refer to the existing sensor driver of the platform in your source code release.

To add a function interface, refer to the following sections:

- ISI API Reference
- ISS Sensor Driver User Space Flow
- Sensor API Reference
- VVCAM Flow in V4L2 Mode (this section)

Both hub and sensor kernel driver must add corresponding interfaces and calls. While porting the sensor, be aware that different sensors in the sensor data sheet have different conversion methods when converting the exposure parameters which are passed down from the 3A modules to the values written in the registers. The sensor data must be accurately defined.

To port the camera sensor, the following steps must be taken as described in the following sections:

1. Create sensor DTB file in kernel.
2. Create sensor V4L2 driver in VVCAM (*VVCAM is the kernel driver integration layer of Vivante*).
3. Create sensor ISI API in ISI Layer.

2.7.1.1 Sensor Driver Software Architecture in V4L2 Mode

The software architecture of the sensor driver in V4L2 Mode is shown in the figure below. The V4L2-subdev driver is defined in file `vvcam/v4l2/sensor/<sensor>/<sensor>_xxxx.c`, where `<sensor>` is the name of the sensor (for example, OV2775).

A device node of the sensor named `v4l-subdevx` can be created in `/dev` for direct access. Function `<sensor>_priv_ioctl()` is used in the kernel space to receive the commands and parameters passed down by the user space through `ioctl()`. It is also used to call the corresponding functions in `<sensor>_xxxx.c` according to the commands.

NOTE

Developers should replace the Vivante V4L2-Subdev Driver with their own sensor as shown in the figure below.

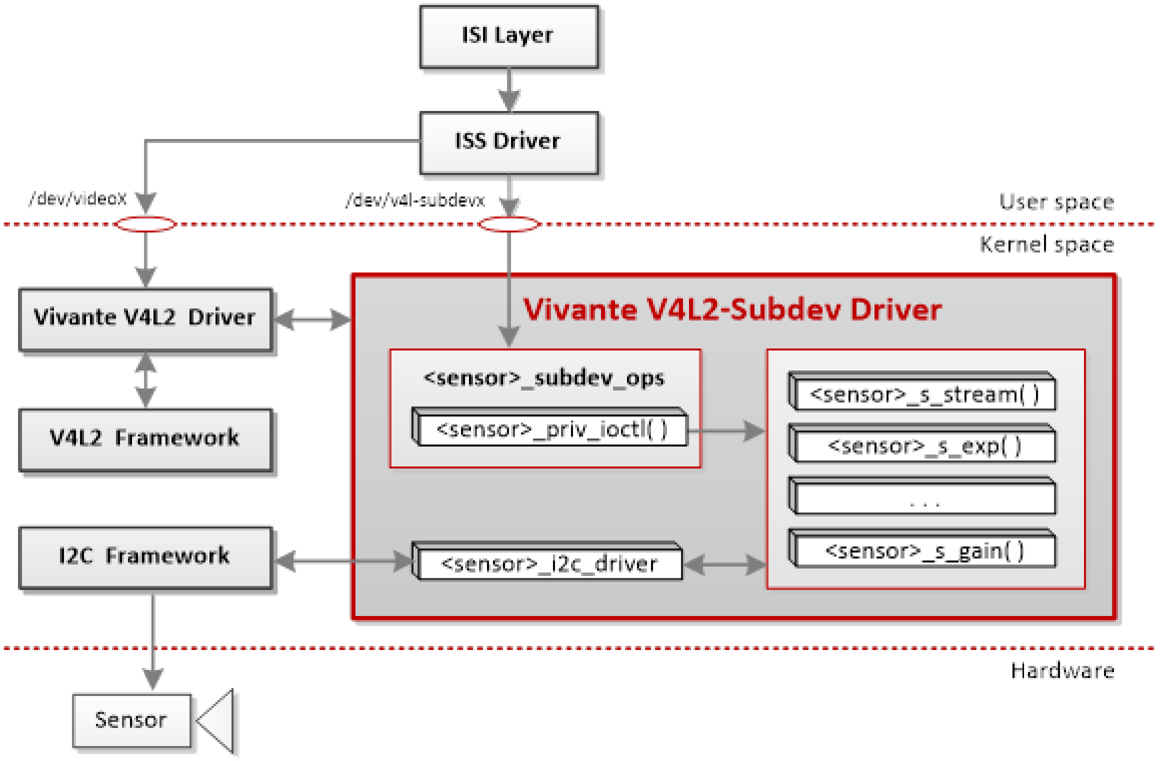


Figure 7. VVCAM Software Architecture in V4L2 Mode

2.7.2 Camera Sensor Porting Setup in V4L2 Mode

2.7.2.1 Create Sensor DTS File in Kernel

When adding a sensor, a new DTS file must be added to support the kernel device driver. If sensor0 is connected to i2C2, add a sensor device to the i2C2 node.

For example:

```
&i2c2 {
    /delete-node/ov5640_mipi@3c;

    ov2775_0: ov2775_mipi@36 {
        compatible = "ovti,ov2775";
        reg = <0x36>;
        pinctrl-names = "default";
        pinctrl-0 = <&pinctrl_csi0_pwn>, <&pinctrl_csi0_rst>, <&pinctrl_csi_mclk>;
        clocks = <&clk IMX8MP_CLK_IPP_DO_CLKO2>;
        clock-names = "csi_mclk";
        assigned-clocks = <&clk IMX8MP_CLK_IPP_DO_CLKO2>;
        assigned-clock-parents = <&clk IMX8MP_CLK_24M>;
        assigned-clock-rates = <24000000>;
        csi_id = <0>;
        pwn-gpios = <&gpio2 11 GPIO_ACTIVE_HIGH>;
        rst-gpios = <&gpio1 6 GPIO_ACTIVE_LOW>;
        mclk = <24000000>;
        mclk_source = <0>;
        status = "okay";

        port {
            ov2775_mipi_0_ep: endpoint {
                data-lanes = <1 2 3 4>;
                clock-lanes = <0>;
                max-pixel-frequency = /bits/ 64 <500000000>;
                remote-endpoint = <&mipi_csi0_ep>;
            };
        };

    };
};
```

2.7.2.2 Create Sensor V4L2 Driver in VVCAM

1. Create struct `vvcam_mode_info_s` for your support modes information.

```
static struct vvcam_mode_info_s pov2775_mode_info[] = {
    {
        .index          = 0,
        .width          = 1920,
        .height         = 1080,
        .hdr_mode       = SENSOR_MODE_LINEAR,
        .bit_width      = 12,
        .data_compress  = {
            .enable = 0,
        },
        .bayer_pattern = BAYER_BGGR,
        .ae_info = {
            .def_frm_len_lines     = 0x466,
            .curr_frm_len_lines    = 0x466,
            .one_line_exp_time_ns  = 29625,

            .max_integration_line  = 0x466 - 4,
            .min_integration_line  = 1,

            .max_again             = 8 * 1024,
            .min_again             = 2 * 1024,
            .max_dgain             = 4 * 1024,
            .min_dgain             = 1.5 * 1024,
            .gain_step             = 4,
            .start_exposure        = 3 * 400 * 1024,
            .cur_fps               = 30 * 1024,
            .max_fps               = 30 * 1024,
            .min_fps               = 5 * 1024,
            .min_afps              = 5 * 1024,
            .int_update_delay_frm  = 1,
            .gain_update_delay_frm = 1,
        },
        .mipi_info = {
            .mipi_lane = 4,
        },
        .preg_data      = ov2775_init_setting_1080p,
        .reg_data_count = ARRAY_SIZE(ov2775_init_setting_1080p),
    },
    {
        .index          = 1,
        .width          = 1920,
        .height         = 1080,
        .hdr_mode       = SENSOR_MODE_HDR_STITCH,
        .stitching_mode = SENSOR_STITCHING_DUAL_DCG,
        .bit_width      = 12,
        .data_compress  = {
            .enable = 0,
        },
        .bayer_pattern  = BAYER_BGGR,
        .ae_info = {
            .def_frm_len_lines        = 0x466,
            .curr_frm_len_lines       = 0x466,
            .one_line_exp_time_ns     = 59167,

            .max_integration_line     = 0x400,
            .min_integration_line     = 1,

            .max_vsintegration_line   = 44,
            .min_vsintegration_line   = 1,

            .max_long_again = 8 * 1024 * DCG_CONVERSION_GAIN,
            .min_long_again = 1 * 1024 * DCG_CONVERSION_GAIN,
            .max_long_dgain = 4 * 1024,
            .min_long_dgain = 2 * 1024,

            .max_again      = 8 * 1024,
            .min_again      = 2 * 1024,
            .max_dgain      = 4 * 1024,
            .min_dgain      = 1.5 * 1024,

            .max_short_again = 8 * 1024,
            .min_short_again = 2 * 1024,
            .max_short_dgain = 4 * 1024,
            .min_short_dgain = 1.5 * 1024,
            .start_exposure  = 3 * 400 * 1024,

            .gain_step       = 4,
            .cur_fps         = 30 * 1024,
            .max_fps         = 30 * 1024,
            .min_fps         = 5 * 1024,
            .min_afps        = 5 * 1024,
            .hdr_ratio       = {
                .ratio_l_s = 8 * 1024,
                .ratio_s_vs = 8 * 1024,
                .accuracy = 1024,
            },
            .int_update_delay_frm = 1,
            .gain_update_delay_frm = 1,
        },
        .mipi_info = {
            .mipi_lane = 4,
        },
        .preg_data = ov2775_init_setting_1080p_hdr,
        .reg_data_count = ARRAY_SIZE(ov2775_init_setting_1080p_hdr),
    },
    {
        .index          = 2,
        .width          = 1920,
        .height         = 1080,
        .hdr_mode       = SENSOR_MODE_HDR_NATIVE,
        .stitching_mode = SENSOR_STITCHING_DUAL_DCG_NOWAIT,
        .bit_width      = 12,
        .data_compress  = {
            .enable = 1,
            .x_bit  = 16,
            .y_bit  = 12,
        },
        .bayer_pattern  = BAYER_BGGR,
        .ae_info = {
            .def_frm_len_lines        = 0x466,
            .curr_frm_len_lines       = 0x466,
            .one_line_exp_time_ns     = 59167,

            .max_integration_line     = 0x466 - 4,
            .min_integration_line     = 1,

            .max_long_again = 8 * 1024 * DCG_CONVERSION_GAIN,
            .min_long_again = 1 * 1024 * DCG_CONVERSION_GAIN,
            .max_long_dgain = 4 * 1024,
            .min_long_dgain = 2 * 1024,

            .max_again      = 8 * 1024 ,
            .min_again      = 2 * 1024,
            .max_dgain      = 4 * 1024,
            .min_dgain      = 1.5 * 1024,

            .start_exposure = 3 * 400 * 1024,

            .gain_step       = 4,
            .cur_fps         = 30 * 1024,
            .max_fps         = 30 * 1024,
            .min_fps         = 5 * 1024,
            .min_afps        = 5 * 1024,
            .hdr_ratio       = {
                .ratio_l_s = 8 * 1024,
                .ratio_s_vs = 8 * 1024,
                .accuracy = 1024,
            },
            .int_update_delay_frm = 1,
            .gain_update_delay_frm = 1,
        },
        .mipi_info = {
            .mipi_lane = 4,
        },
        .preg_data = ov2775_1080p_native_hdr_regs,
        .reg_data_count = ARRAY_SIZE(ov2775_1080p_native_hdr_regs),
    },
};
```

2. Register the new sensor V4L2 driver.

```
static int ov2775_probe(struct i2c_client *client,
                        const struct i2c_device_id *id)
{
    int retval;
    struct device *dev = &client->dev;
    struct v4l2_subdev *sd;
    struct ov2775 *sensor;
    u32 chip_id = 0;
    u8 reg_val = 0;

    pr_info("enter %s\n", __func__);

    sensor = devm_kmalloc(dev, sizeof(*sensor), GFP_KERNEL);
    if (!sensor)
        return -ENOMEM;
    memset(sensor, 0, sizeof(*sensor));

    sensor->i2c_client = client;

    sensor->pwn_gpio = of_get_named_gpio(dev->of_node, "pwn-gpios", 0);
    if (!gpio_is_valid(sensor->pwn_gpio))
        dev_warn(dev, "No sensor pwdn pin available");
    else {
        retval = devm_gpio_request_one(dev, sensor->pwn_gpio,
                        GPIOF_OUT_INIT_HIGH,
                        "ov2775_mipi_pwdn");
        if (retval < 0) {
            dev_warn(dev, "Failed to set power pin\n");
            dev_warn(dev, "retval=%d\n", retval);
            return retval;
        }
    }

    sensor->rst_gpio = of_get_named_gpio(dev->of_node, "rst-gpios", 0);
    if (!gpio_is_valid(sensor->rst_gpio))
        dev_warn(dev, "No sensor reset pin available");
    else {
        retval = devm_gpio_request_one(dev, sensor->rst_gpio,
                        GPIOF_OUT_INIT_HIGH,
                        "ov2775_mipi_reset");
        if (retval < 0) {
            dev_warn(dev, "Failed to set reset pin\n");
            return retval;
        }
    }

    sensor->sensor_clk = devm_clk_get(dev, "csi_mclk");
    if (IS_ERR(sensor->sensor_clk)) {
        sensor->sensor_clk = NULL;
        dev_err(dev, "clock-frequency missing or invalid\n");
        return PTR_ERR(sensor->sensor_clk);
    }

    retval = of_property_read_u32(dev->of_node, "mclk", &(sensor->mclk));
    if (retval) {
        dev_err(dev, "mclk missing or invalid\n");
        return retval;
    }

    retval = of_property_read_u32(dev->of_node, "mclk_source",
                (u32 *)&(sensor->mclk_source));
    if (retval) {
        dev_err(dev, "mclk_source missing or invalid\n");
        return retval;
    }

    retval = of_property_read_u32(dev->of_node, "csi_id", &(sensor->csi_id));
    if (retval) {
        dev_err(dev, "csi id missing or invalid\n");
        return retval;
    }

    retval = ov2775_retrieve_capture_properties(sensor,&sensor->ocp);
    if (retval) {
        dev_warn(dev, "retrive capture properties error\n");
    }

    sensor->io_regulator = devm_regulator_get(dev, "DOVDD");
    if (IS_ERR(sensor->io_regulator)) {
        dev_err(dev, "cannot get io regulator\n");
        return PTR_ERR(sensor->io_regulator);
    }

    sensor->core_regulator = devm_regulator_get(dev, "DVDD");
    if (IS_ERR(sensor->core_regulator)) {
        dev_err(dev, "cannot get core regulator\n");
        return PTR_ERR(sensor->core_regulator);
    }

    sensor->analog_regulator = devm_regulator_get(dev, "AVDD");
    if (IS_ERR(sensor->analog_regulator)) {
        dev_err(dev, "cannot get analog  regulator\n");
        return PTR_ERR(sensor->analog_regulator);
    }

    retval = ov2775_regulator_enable(sensor);
    if (retval) {
        dev_err(dev, "regulator enable failed\n");
        return retval;
    }

    ov2775_set_clk_rate(sensor);
    retval = clk_prepare_enable(sensor->sensor_clk);
    if (retval < 0) {
        dev_err(dev, "%s: enable sensor clk fail\n", __func__);
        goto probe_err_regulator_disable;
    }

    retval = ov2775_power_on(sensor);
    if (retval < 0) {
        dev_err(dev, "%s: sensor power on fail\n", __func__);
        goto probe_err_regulator_disable;
    }

    ov2775_reset(sensor);

    ov2775_read_reg(sensor, 0x300a, &reg_val);
    chip_id |= reg_val << 8;
    ov2775_read_reg(sensor, 0x300b, &reg_val);
    chip_id |= reg_val;
    if (chip_id != 0x2770) {
        pr_warn("camera ov2775 is not found\n");
        retval = -ENODEV;
        goto probe_err_power_off;
    }

    sd = &sensor->subdev;
    v4l2_i2c_subdev_init(sd, client, &ov2775_subdev_ops);
    sd->flags |= V4L2_SUBDEV_FL_HAS_DEVNODE;
    sd->dev = &client->dev;
    sd->entity.ops = &ov2775_sd_media_ops;
    sd->entity.function = MEDIA_ENT_F_CAM_SENSOR;
    sensor->pads[OV2775_SENS_PAD_SOURCE].flags = MEDIA_PAD_FL_SOURCE;
    retval = media_entity_pads_init(&sd->entity,
                OV2775_SENS_PADS_NUM,
                sensor->pads);
    if (retval < 0)
        goto probe_err_power_off;

    retval = v4l2_async_register_subdev_sensor_common(sd);
    if (retval < 0) {
        dev_err(&client->dev,"%s--Async register failed, ret=%d\n",
            __func__,retval);
        goto probe_err_free_entiny;
    }

    memcpy(&sensor->cur_mode, &pov2775_mode_info[0],
            sizeof(struct vvcam_mode_info_s));

    mutex_init(&sensor->lock);
    pr_info("%s camera mipi ov2775, is found\n", __func__);

    return 0;

probe_err_free_entiny:
    media_entity_cleanup(&sd->entity);

probe_err_power_off:
    ov2775_power_off(sensor);

probe_err_regulator_disable:
    ov2775_regulator_disable(sensor);

    return retval;
}
```

3. Implement the v4l2_subdev_ops data structure.

```
static struct v4l2_subdev_video_ops ov2775_subdev_video_ops = {
    .s_stream = ov2775_s_stream,
};

static const struct v4l2_subdev_pad_ops ov2775_subdev_pad_ops = {
    .enum_mbus_code = ov2775_enum_mbus_code,
    .set_fmt = ov2775_set_fmt,
    .get_fmt = ov2775_get_fmt,
};

static struct v4l2_subdev_core_ops ov2775_subdev_core_ops = {
    .s_power = ov2775_s_power,
    .ioctl = ov2775_priv_ioctl,
};

static struct v4l2_subdev_ops ov2775_subdev_ops = {
    .core  = &ov2775_subdev_core_ops,
    .video = &ov2775_subdev_video_ops,
    .pad   = &ov2775_subdev_pad_ops,
};
```

4. Implement the sensor private IOCTL.

```
static long ov2775_priv_ioctl(struct v4l2_subdev *sd,
                              unsigned int cmd,
                              void *arg)
{
    struct i2c_client *client = v4l2_get_subdevdata(sd);
    struct ov2775 *sensor = client_to_ov2775(client);
    long ret = 0;
    struct vvcam_sccb_data_s sensor_reg;

    mutex_lock(&sensor->lock);
    switch (cmd){
    case VVSENSORIOC_S_POWER:
        ret = 0;
        break;
    case VVSENSORIOC_S_CLK:
        ret = 0;
        break;
    case VVSENSORIOC_G_CLK:
        ret = ov2775_get_clk(sensor,arg);
        break;
    case VVSENSORIOC_RESET:
        ret = 0;
        break;
    case VIDIOC_QUERYCAP:
        ret = ov2775_query_capability(sensor, arg);
        break;
    case VVSENSORIOC_QUERY:
        ret = ov2775_query_supports(sensor, arg);
        break;
    case VVSENSORIOC_G_CHIP_ID:
        ret = ov2775_get_sensor_id(sensor, arg);
        break;
    case VVSENSORIOC_G_RESERVE_ID:
        ret = ov2775_get_reserve_id(sensor, arg);
        break;
    case VVSENSORIOC_G_SENSOR_MODE:
        ret = ov2775_get_sensor_mode(sensor, arg);
        break;
    case VVSENSORIOC_S_SENSOR_MODE:
        ret = ov2775_set_sensor_mode(sensor, arg);
        break;
    case VVSENSORIOC_S_STREAM:
        ret = ov2775_s_stream(&sensor->subdev, *(int *)arg);
        break;
    case VVSENSORIOC_WRITE_REG:
        ret = copy_from_user(&sensor_reg, arg,
            sizeof(struct vvcam_sccb_data_s));
        ret |= ov2775_write_reg(sensor, sensor_reg.addr,
            sensor_reg.data);
        break;
    case VVSENSORIOC_READ_REG:
        ret = copy_from_user(&sensor_reg, arg,
            sizeof(struct vvcam_sccb_data_s));
        ret |= ov2775_read_reg(sensor, sensor_reg.addr,
            (u8 *)&sensor_reg.data);
        ret |= copy_to_user(arg, &sensor_reg,
            sizeof(struct vvcam_sccb_data_s));
        break;
    case VVSENSORIOC_S_LONG_EXP:
        ret = ov2775_set_lexp(sensor, *(u32 *)arg);
        break;
    case VVSENSORIOC_S_EXP:
        ret = ov2775_set_exp(sensor, *(u32 *)arg);
        break;
    case VVSENSORIOC_S_VSEXP:
        ret = ov2775_set_vsexp(sensor, *(u32 *)arg);
        break;
    case VVSENSORIOC_S_LONG_GAIN:
        ret = ov2775_set_lgain(sensor, *(u32 *)arg);
        break;
    case VVSENSORIOC_S_GAIN:
        ret = ov2775_set_gain(sensor, *(u32 *)arg);
        break;
    case VVSENSORIOC_S_VSGAIN:
        ret = ov2775_set_vsgain(sensor, *(u32 *)arg);
        break;
    case VVSENSORIOC_S_FPS:
        ret = ov2775_set_fps(sensor, *(u32 *)arg);
        break;
    case VVSENSORIOC_G_FPS:
        ret = ov2775_get_fps(sensor, (u32 *)arg);
        break;
    case VVSENSORIOC_S_HDR_RADIO:
        ret = ov2775_set_ratio(sensor, arg);
        break;
    case VVSENSORIOC_S_BLC:
        ret = ov2775_set_blc(sensor, arg);
        break;
    case VVSENSORIOC_S_WB:
        ret = ov2775_set_wb(sensor, arg);
        break;
    case VVSENSORIOC_G_EXPAND_CURVE:
        ret = ov2775_get_expand_curve(sensor, arg);
        break;
    case VVSENSORIOC_S_TEST_PATTERN:
        ret= ov2775_set_test_pattern(sensor, arg);
        break;
    default:
        break;
    }

    mutex_unlock(&sensor->lock);
    return ret;
}
```

2.7.2.3 Create Sensor ISI API in ISI Layer

1. `Typedef` your `<sensor>_Context_t` for the sensor handle.

```
typedef struct OV2755_Context_s
{
    IsiSensorContext_t  IsiCtx;
    struct vvcam_mode_info_s CurMode;
    IsiSensorAeInfo_t AeInfo;
    IsiSensorIntTime_t IntTime;
    uint32_t LongIntLine;
    uint32_t IntLine;
    uint32_t ShortIntLine;
    IsiSensorGain_t SensorGain;
    uint32_t minAfps;
    uint64_t AEStartExposure;
} OV2775_Context_t;
```

2. Implement `IsiCamDrvConfig` for the sensor library callback function.

   Define the IsiCamDrvConfig_s data structure. Data members defined in this data structure include the sensor ID (CameraDriverID) and the function pointer to the IsiSensor data structure. Using the address of the `IsiCamDrvConfig_t` structure, the driver can then access the sensor API attached to the function pointer.

```
IsiCamDrvConfig_t IsiCamDrvConfig = {
.CameraDriverID = 0x2770,
.pIsiHalQuerySensor = <sensor>_IsiHalQuerySensorIss,
.pfIsiGetSensorIss  = <sensor>_IsiGetSensorIss
}
```

NOTE

- `IsiCamDrvConfig` is defined in file: `units/isi/drv/<sensor>/source/<sensor>.c`.
- `<sensor>_IsiHalQuerySensorIss()` uses the IOCTL command `VVSENSORIOC_QUERY` to get all the modes supported by `<sensor>`.

`<sensor>_IsiGetSensorIss()` can initialize the IsiSensor data structure. It is called by an upper-level application described in the ISS Sensor Driver User Space Flow section. Then the application can get the address of all the callback functions.

`<sensor>_IsiGetSensorIss` is defined as follows.

```
RESULT <sensor>_IsiGetSensorIss(IsiSensor_t *pIsiSensor)
…
pIsiSensor->pIsiCreateSensorIss          = <sensor>_IsiCreateSensorIss;
pIsiSensor->pIsiReleaseSensorIss         = <sensor>_IsiReleaseSensorIss;
pIsiSensor->pIsiRegisterReadIss          = <sensor>_IsiRegisterReadIss;
pIsiSensor->pIsiRegisterWriteIss         = <sensor>_IsiRegisterWriteIss;
pIsiSensor->pIsiGetSensorModeIss         = <sensor>_IsiGetSensorModeIss;

…
};
```

NOTE

It is described in the Sensor API Reference section.

2.7.3 Native HDR Mode Porting

For native HDR mode, two-exposure HDRs and three-exposure sensor HDRs are supported with the following caveats:

1. When a new native HDR mode is added, `hdr_mode` must be set to `SENSOR_MODE_HDR_NATIVE`, and `stitching_mode` must be set to the stitching mode corresponding to the sensor in use.

```
static struct vvcam_mode_info_s pov2775_mode_info[] = {
…
    {
        .index          = 2,
        .width          = 1920,
        .height         = 1080,
        .hdr_mode       = SENSOR_MODE_HDR_NATIVE,
        .stitching_mode = SENSOR_STITCHING_DUAL_DCG_NOWAIT,
        .bit_width      = 12,
        .data_compress  = {
            .enable = 1,
            .x_bit  = 16,
            .y_bit  = 12,
        },
        .bayer_pattern  = BAYER_BGGR,
        .ae_info = {
            .def_frm_len_lines        = 0x466,
            .curr_frm_len_lines       = 0x466,
            .one_line_exp_time_ns     = 59167,

            .max_integration_line     = 0x466 - 4,
            .min_integration_line     = 1,

            .max_long_again = 8 * 1024 * DCG_CONVERSION_GAIN,
            .min_long_again = 1 * 1024 * DCG_CONVERSION_GAIN,
            .max_long_dgain = 4 * 1024,
            .min_long_dgain = 2 * 1024,

            .max_again      = 8 * 1024,
            .min_again      = 2 * 1024,
            .max_dgain      = 4 * 1024,
            .min_dgain      = 1.5 * 1024,

            .start_exposure = 3 * 400 * 1024,
            .gain_step       = 4,
            .cur_fps         = 30 * 1024,
            .max_fps         = 30 * 1024,
            .min_fps         =  5 * 1024,
            .min_afps        =  5 * 1024,
            .hdr_ratio       = {
                .ratio_l_s = 8 * 1024,
                .ratio_s_vs = 8 * 1024,
                .accuracy = 1024,
            },
            .int_update_delay_frm = 1,
            .gain_update_delay_frm = 1,
        },
        .mipi_info = {
            .mipi_lane = 4,
        },
        .preg_data = ov2775_1080p_native_hdr_regs,
        .reg_data_count = ARRAY_SIZE(ov2775_1080p_native_hdr_regs),
    },
};
```

2. Set the Native HDR default stitching ratio for two-exposure, use `ratio_s_vs` (long/short) as the stitching ratio for three-exposure, and set both `ratio_l_s` (long/normal) and `ratio_s_vs` (normal/short).

```
static struct vvcam_mode_info_s pov2775_mode_info[] = {
…
    {
        .index          = 2,
        .width          = 1920,
        .height         = 1080,
        .hdr_mode       = SENSOR_MODE_HDR_NATIVE,
        .stitching_mode = SENSOR_STITCHING_DUAL_DCG_NOWAIT,
        .bit_width      = 12,
        .data_compress  = {
            .enable = 1,
            .x_bit  = 16,
            .y_bit  = 12,
        },
        .bayer_pattern  = BAYER_BGGR,
        .ae_info = {
            .def_frm_len_lines        = 0x466,
            .curr_frm_len_lines       = 0x466,
            .one_line_exp_time_ns     = 59167,

            .max_integration_line     = 0x466 - 4,
            .min_integration_line     = 1,

            .max_long_again = 8 * 1024 * DCG_CONVERSION_GAIN,
            .min_long_again = 1 * 1024 * DCG_CONVERSION_GAIN,
            .max_long_dgain = 4 * 1024,
            .min_long_dgain = 2 * 1024,

            .max_again      = 8 * 1024,
            .min_again      = 2 * 1024,
            .max_dgain      = 4 * 1024,
            .min_dgain      = 1.5 * 1024,

            .start_exposure = 3 * 400 * 1024,

            .gain_step       = 4,
            .cur_fps         = 30 * 1024,
            .max_fps         = 30 * 1024,
            .min_fps         =  5 * 1024,
            .min_afps        =  5 * 1024,
            .hdr_ratio       = {
                .ratio_l_s = 8 * 1024,
                .ratio_s_vs = 8 * 1024,
                .accuracy = 1024,
            },
            .int_update_delay_frm = 1,
            .gain_update_delay_frm = 1,
        },
        .mipi_info = {
            .mipi_lane = 4,
        },
        .preg_data = ov2775_1080p_native_hdr_regs,
        .reg_data_count = ARRAY_SIZE(ov2775_1080p_native_hdr_regs),
    },
};
```

3. Generally, native HDR performs data compression at the sensor end, and the decompression function of the ISP module must be enabled. Setting `data_compress.enable = 1` means the sensor data has been compressed, and the data is compressed from `x_bit` to `y_bit`. The decompression curve API must be implemented as described in the Sensor Compand Curve section.

```
static struct vvcam_mode_info_s pov2775_mode_info[] = {
…
    {
        .index          = 2,
        .width          = 1920,
        .height         = 1080,
        .hdr_mode       = SENSOR_MODE_HDR_NATIVE,
        .stitching_mode = SENSOR_STITCHING_DUAL_DCG_NOWAIT,
        .bit_width      = 12,
        .data_compress  = {
            .enable = 1,
            .x_bit  = 16,
            .y_bit  = 12,
        },
        .bayer_pattern  = BAYER_BGGR,
        .ae_info = {
            .def_frm_len_lines        = 0x466,
            .curr_frm_len_lines       = 0x466,
            .one_line_exp_time_ns     = 59167,

            .max_integration_line     = 0x466 - 4,
            .min_integration_line     = 1,

            .max_long_again = 8 * 1024 * DCG_CONVERSION_GAIN,
            .min_long_again = 1 * 1024 * DCG_CONVERSION_GAIN,
            .max_long_dgain = 4 * 1024,
            .min_long_dgain = 2 * 1024,

            .max_again      = 8 * 1024,
            .min_again      = 2 * 1024,
            .max_dgain      = 4 * 1024,
            .min_dgain      = 1.5 * 1024,

            .start_exposure = 3 * 400 * 1024,
            .gain_step       = 4,
            .cur_fps         = 30 * 1024,
            .max_fps         = 30 * 1024,
            .min_fps         = 5 * 1024,
            .min_afps        = 5 * 1024,
            .hdr_ratio       = {
                .ratio_l_s = 8 * 1024,
                .ratio_s_vs = 8 * 1024,
                .accuracy = 1024,
            },
            .int_update_delay_frm = 1,
            .gain_update_delay_frm = 1,
        },
        .mipi_info = {
            .mipi_lane = 4,
        },
        .preg_data = ov2775_1080p_native_hdr_regs,
        .reg_data_count = ARRAY_SIZE(ov2775_1080p_native_hdr_regs),
    },
};
```

4. Native HDR BLS and WB usually need to be done on the sensor side, so it is necessary to realize the sensor WB and BLS interface and configure ISP to use sensor BLS and WB as described in Sensor White Balance and Black Level Correction (BLC) section.

2.7.4 Sensor Compand Curve

In the vvcam_mode_info_t data structure, the sensor_data_compress_t data structure describes whether the sensor data is compressed or not. If the sensor data is compressed, the `sensor_data_compress_t data` structure describes the data compression type.

NOTE

- The maximum bit width for the expand module is 20 bits.
- To remove the expand module, set `data_compress.enable = 0`.

Example:

For OV2775 native HDR, sensor data is compressed from 16 bits to 12 bits. So,

x_bit =16 and y_bit=12.

It determines the type of decompression curve used by the compand module.

```
{
.index = 2,
.width = 1920,
.height = 1080,
.fps = 30,
.hdr_mode = SENSOR_MODE_HDR_NATIVE,
.bit_width = 12,
.data_compress.enable = 1,
.data_compress.x_bit = 16,
.data_compress.y_bit = 12,
.bayer_pattern = BAYER_BGGR,
.ae_info = {
.DefaultFrameLengthLines = 0x466,
.one_line_exp_time_ns = 59167,
.max_interrgation_time = 0x466 - 2,
.min_interrgation_time = 1,
.gain_accuracy = 1024,
.max_gain = 21 * 1024,
.min_gain = 3 * 1024,
},
.preg_data = ov2775_1080p_native_hdr_regs,
.reg_data_count = ARRAY_SIZE(ov2775_1080p_native_hdr_regs),
}
```

ISP decompresses according to the specified compression method. If the sensor is compressed from 16-bit to 12-bit, the compand module calls the `<sensor>_get_expand_curve()` function to get the 12-bit to 16-bit expand curve as defined in the sensor_expand_curve_s data structure.

See below the limitations of the expand curve.

```
(1 << pexpand_curve->expand_px[i]) =
pexpand_curve->expand_x_data[i+1] - pexpand_curve->expand_x_data[i]
```

For example, OV2775 expand curve.

The OV2775 has a data compression from 16-bit to 12-bit by a 4-piece piece-wise linear (PWL) curve. The following formula defines the curve and is shown in the following figure.

$$y_{out\_12b} = \begin{cases} \dfrac{y_{in\_16b}}{2}, & y_{in\_16b} < 1024 \\ \dfrac{y_{in\_16b}}{4} + 256, & 1024 \leq y_{in\_16b} < 2048 \\ \dfrac{y_{in\_16b}}{8} + 512, & 2048 \leq y_{in\_16b} < 16384 \\ \dfrac{y_{in\_16b}}{32} + 2048, & y_{in\_16b} \geq 16384 \end{cases}$$

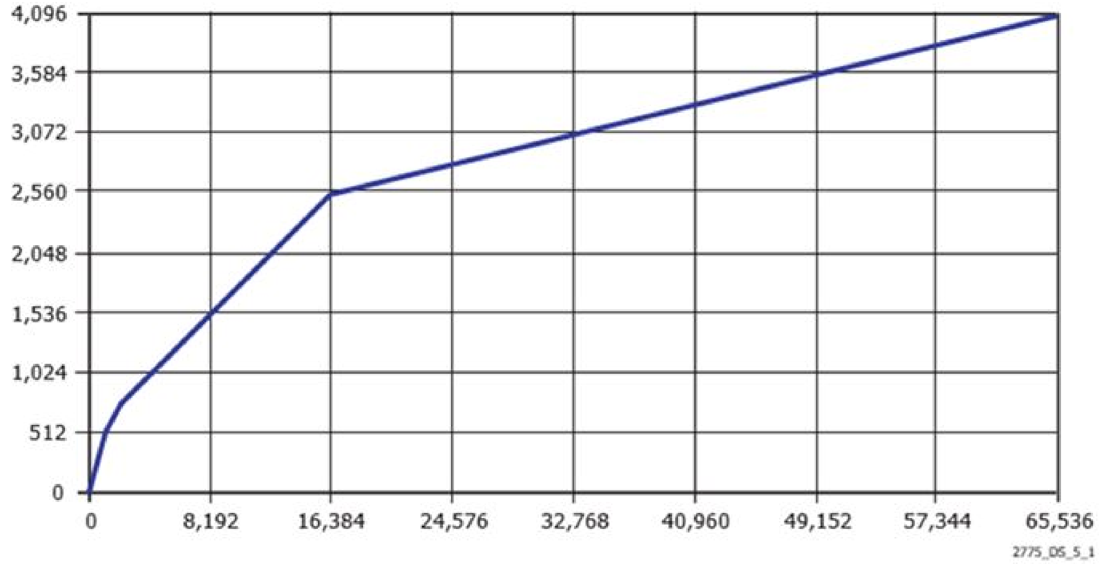


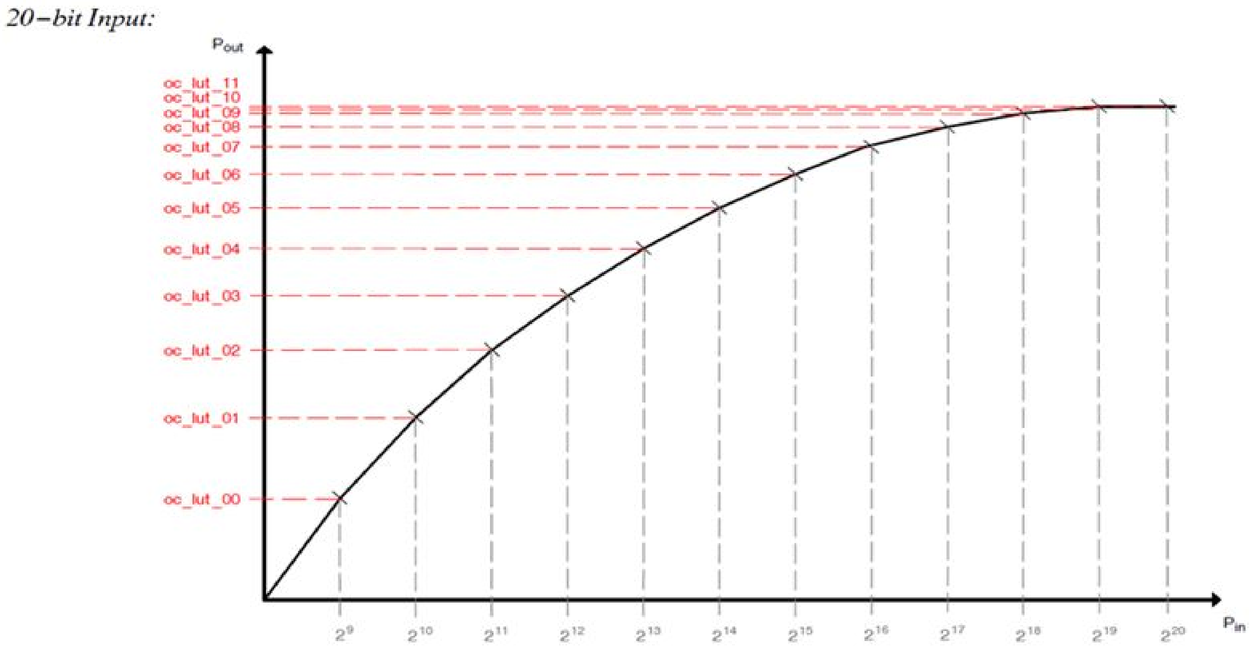
Figure 8. 16-bit to 12-bit PWL compression

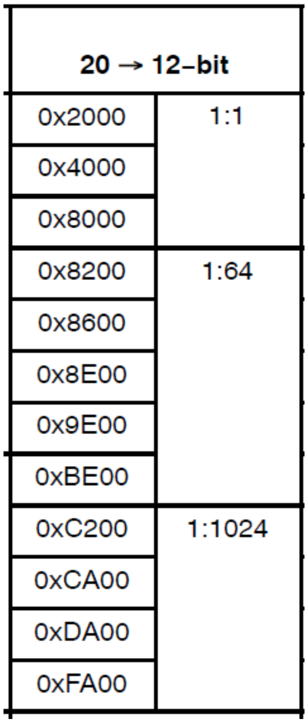
The backend processor can decompress 12-bit data to 16-bit data using the following formula.

$$y_{out\_16b} = \begin{cases} 2 \times y_{in\_12b} & y_{in\_12b} < 512 \\ 4 \times (y_{in\ 12b} - 256), & 512 \leq y_{in\ 12b} < 768 \\ 8 \times (y_{in\ 12b} - 512), & 768 \leq y_{in\ 12b} < 2560 \\ 32 \times (y_{in\ 12b} - 2048), & y_{in\_12b} \geq 2560 \end{cases}$$

```
int ov2775_get_expand_curve(struct ov2775 *sensor,
sensor_expand_curve_t* pexpand_curve)
{
int i;
if ((pexpand_curve->x_bit) == 12 && (pexpand_curve->y_bit == 16))
{
uint8_t expand_px[64] = {6,6,6,6,6,6,6,6,6,6,6,6,6,6,6,6,
6,6,6,6,6,6,6,6,6,6,6,6,6,6,6,6,
6,6,6,6,6,6,6,6,6,6,6,6,6,6,6,6,
6,6,6,6,6,6,6,6,6,6,6,6,6,6,6,6};
memcpy(pexpand_curve->expand_px,expand_px,sizeof(expand_px));
pexpand_curve->expand_x_data[0] = 0;
pexpand_curve->expand_y_data[0] = 0;
for(i = 1; i < 65; i++)
{
pexpand_curve->expand_x_data[i] =
(1 << pexpand_curve->expand_px[i-1]) +
pexpand_curve->expand_x_data[i-1];
if (pexpand_curve->expand_x_data[i] < 512)
{
pexpand_curve->expand_y_data[i] =
pexpand_curve->expand_x_data[i] << 1;
}
else if (pexpand_curve->expand_x_data[i] < 768)
{
```

```
pexpand_curve->expand_y_data[i] =
(pexpand_curve->expand_x_data[i] - 256) << 2;
}
else if (pexpand_curve->expand_x_data[i] < 2560)
{
pexpand_curve->expand_y_data[i] =
(pexpand_curve->expand_x_data[i] - 512) << 3;
}
else
{
pexpand_curve->expand_y_data[i] =
(pexpand_curve->expand_x_data[i] - 2048) << 5;
}
}
return 0;
}
return (-1);
}
ar0820 20-bit to12-bit as 16-bit output:
```





20 → 12-bit	
0x2000	1:1
0x4000	
0x8000	
0x8200	1:64
0x8600	
0x8E00	
0x9E00	
0xBE00	
0xC200	1:1024
0xCA00	
0xDA00	
0xFA00	

The automatic values of the knee-points can be read back from the `oc_lut_XX` registers but cannot be changed (writes to the `oc_lut_XX` registers are ignored). All the knee-point registers are MSB-aligned. For example, a programmed value of 0x2000 acts as 0x200 when the output is 12-bit data and acts as 0x2000 when the output is 16-bit data.

The expand curve is defined as follows:

```
expand_px[64] = {13, 13, 14, 9, 10, 11, 12, 13,
10, 11, 12, 13, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0,};
expand_x_data[65] ={0,0x2000,0x4000,0x8000,0x8200,0x8600,0x8e00,0x9e00,0xbe00,
0xc200,0xca00,0xda00,0xfa00,0xfa01,0xfa02,0xfa03,0xfa04,
0xfa05,0xfa06,0xfa07,0xfa08,0xfa09,0xfa0a,0xfa0b,0xfa0c,
0xfa0d,0xfa0e,0xfa0f,0xfa10,0xfa11,0xfa12,0xfa13,0xfa14,
0xfa15,0xfa16,0xfa17,0xfa18,0xfa19,0xfa1a,0xfa1b,0xfa1c,
0xfa1d,0xfa1e,0xfa1f,0xfa20,0xfa21,0xfa22,0xfa23,0xfa24,
0xfa25,0xfa26,0xfa27,0xfa28,0xfa29,0xfa2a,0xfa2b,0xfa2c,
0xfa2d,0xfa2e,0xfa2f,0xfa30,0xfa31,0xfa32,0xfa33,0xfa34};
expand_y_data[65] = {0x00,
0x200, 0x400, 0x800, 0x1000, 0x2000, 0x4000, 0x8000, 0x10000,
0x20000, 0x40000, 0x80000, 0x100000, 0x100000, 0x100000, 0x100000,0x100000,
0x100000,0x100000,0x100000,0x100000, 0x100000, 0x100000, 0x100000,0x100000,
0x100000,0x100000,0x100000,0x100000, 0x100000, 0x100000, 0x100000,0x100000,
0x100000,0x100000,0x100000,0x100000, 0x100000, 0x100000, 0x100000,0x100000,
0x100000,0x100000,0x100000,0x100000, 0x100000, 0x100000, 0x100000,0x100000,
0x100000,0x100000,0x100000,0x100000, 0x100000, 0x100000, 0x100000,0x100000,
0x100000,0x100000,0x100000,0x100000, 0x100000, 0x100000, 0x100000,0x100000};
```

NOTE

Sensor data is 16-bit output, so `data_compress` must set x_bit = 20 and y_bit = 16.

```
.data_compress = {
.enable = 1,
.x_bit = 20,
.y_bit = 16,
},
```

2.7.5 Sensor White Balance and Black Level Correction (BLC)

ISP AWB is used in normal mode. In native HDR mode, black level and white balance calibration should be done before the image synthesis at the sensor.

To enable the WB mode of the sensor, an interface must be provided to set the AWB mode to `ISI_SENSOR_AWB_MODE_SENSOR`. In this `ISI_SENSOR_AWB_MODE_SENSOR` mode, ISP does not perform white balance and black level reduction. Set the sensor for black level and white balance calibration using VVSENSORIOC_S_WB and VVSENSORIOC_S_BLC.

Example：

```
static RESULT OV2775_IsiGetSensorAWBModeIss(IsiSensorHandle_t handle,
IsiSensorAwbMode_t *pawbmode)
{
OV2775_Context_t *pOV2775Ctx = (OV2775_Context_t *) handle;
if (pOV2775Ctx == NULL || pOV2775Ctx->IsiCtx.HalHandle == NULL) {
return RET_NULL_POINTER;
}
if (pOV2775Ctx->SensorMode.hdr_mode == SENSOR_MODE_HDR_NATIVE) {
*pawbmode = ISI_SENSOR_AWB_MODE_SENSOR;
}
else {
*pawbmode = ISI_SENSOR_AWB_MODE_NORMAL;
}
return RET_SUCCESS;
}
```

2.8 Camera Timing Issue Solution

One of the following situations may occur for the dual sensor configuration:

- The second sensor FPS is different from the first sensor.
- The second sensor image displays jitter.
- The second sensor initial brightness of the image changes from time to time.

Solution:

The timing may be adjusted to solve this problem in the following example (for example, ov2775):

1. Read the sensor register as shown in the figure below.
2. Calculate the MIPI clock and Pclk.
3. Reduce the size of the sensor PLL multiplier slightly until the image returns to normal and the FPS of the two sensors is the same.
4. After the image returns to normal, adjust the FPS though sensor HTS/VTS.

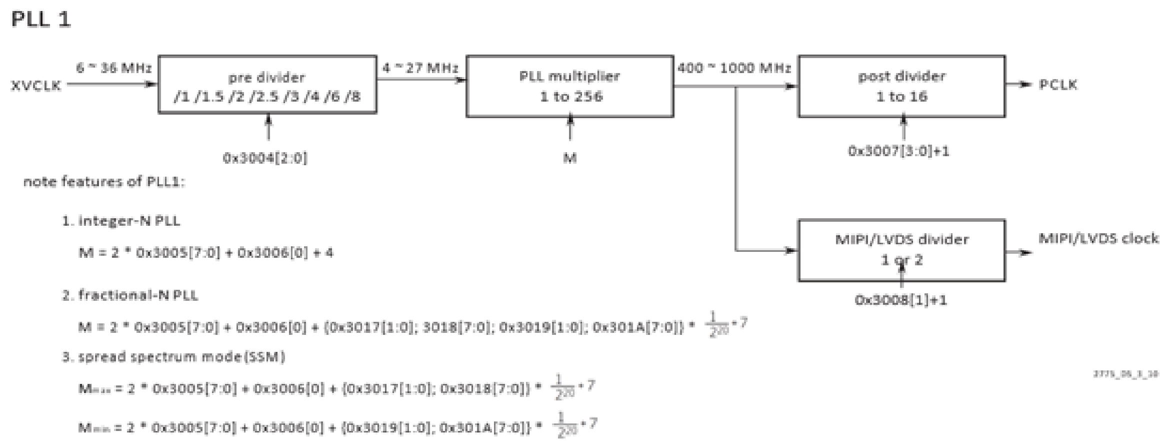

PLL 1
XVCLK
6 ~ 36 MHz
pre divider
/1 /1.5 /2 /2.5 /3 /4 /6 /8
0x3004[2:0]
4 ~ 27 MHz
PLL multiplier
1 to 256
M
400 ~ 1000 MHz
post divider
1 to 16
0x3007[3:0]+1
PCLK
MIPI/LVDS divider
1 or 2
0x3008[1]+1
MIPI/LVDS clock
note features of PLL1:
1. integer-N PLL
M = 2 * 0x3005[7:0] + 0x3006[0] + 4
2. fractional-N PLL
M = 2 * 0x3005[7:0] + 0x3006[0] + {0x3017[1:0]; 3018[7:0]; 0x3019[1:0]; 0x301A[7:0]} * 1/2^20 * 7
3. spread spectrum mode(SSM)
Mmax = 2 * 0x3005[7:0] + 0x3006[0] + {0x3017[1:0]; 0x3018[7:0]} * 1/2^20 * 7
Mmin = 2 * 0x3005[7:0] + 0x3006[0] + {0x3019[1:0]; 0x301A[7:0]} * 1/2^20 * 7

Figure 9. PLL Control Diagram

Chapter 3
ISP Using V4L2 Interface

3.1 Overview

This document describes the ISP software Application Programming Interface (API) using Video For Linux 2. The ISP software V4L2 API controls the ISP hardware, sensor hardware, and its calibration data from the Linux standard API. The kernel V4L2 driver handles the API commands and requests from the V4L2 user application. It communicates to the ISP software stack and delivers image buffers to the V4L2 user application.

Currently, there are no deprecated functions in this API.

3.1.1 Requirements/dependencies

- Linux environment is compatible with V4L2.

3.1.2 Supported features

ISP features which are listed in Table 7 are currently supported in the ISP V4L2 API.

Table 7. ISP features

Feature	Abbreviation
Auto Focus	AF
Auto Exposure	AE
Auto White Balance	AWB
Auto Video Stabilization	AVS
Black Level Subtraction	BLS
Chromatic Aberration Correction	CAC
Color Noise Reduction	CNR
Color Processing	CPROC
Demosaic	--
Defect Pixel Cluster Correction	DPCC
De-noising Pre-filter	DPF
High Dynamic Range	HDR
Image Effect	IE
Lens Shade Correction	LSC
Noise Reduce 2D	2DNR
Noise Reduce 3D	3DNR
Wide Dynamic Range	WDR

Sensor features: Additional functionality provided in future releases.

3.2 V4L2 API components

The ISP software V4L2 API is written in ANSI C++ code and is defined in the `v4l2/video/sub` folder. All commands are performed in the user space using an IOCTL interface which calls kernel space actions directly. The IOCTL control words are described in the IOCTL Interface and Commands.

The ISP software V4L2 API components are defined in the following sections:

- Buffer API
- Event API
- Feature control API

3.2.1 IOCTL interface and commands

V4L2 provides Input and Output Control (IOCTL) interfaces to communicate directly with device drivers. Table 8 lists key IOCTLs relevant to the ISP V4L2 software. Each IOCTL command corresponds to an operation function.

Table 8. Key video IOTCLs

IOCTL	Type	Description
`VIDIOC_QUERYCAP`	`.vidioc_querycap`	Query the capabilities of the driver, such as `V4L2_CAP_STREAMING`
`VIDIOC_ENUM_FRAMESIZES`	`vidioc_enum_framesizes`	Enum support resolution
`VIDIOC_S_FMT`	`.vidioc_s_fmt_*`	Set format information
`VIDIOC_REQBUFS`	`.vidioc_reqbufs`	Request buffers. Buffer types: DMA, MMAP, USER_PTR
`VIDIOC_QBUF`	`.vidioc_qbuf`	Enqueue buffer to kernel, then the driver fills this buffer
`VIDIOC_QUERYBUF`	`.vidioc_querybuf`	Get buffer information from the kernel and mmap
`VIDIOC_DQBUF`	`.vidioc_dqbuf`	De-queue the buffer from the kernel. User gets frame data
`VIDIOC_STREAMON`	`.vidioc_streamon`	Start stream
`VIDIOC_STREAMOFF`	`.vidioc_streamoff`	Close stream
`VIDIOC_G_EXT_CTRLS`	`.vidioc_g_ext_ctrls`	Get feature control commands
`VIDIOC_S_EXT_CTRLS`	`.vidioc_s_ext_ctrls`	Set feature control commands

3.2.2 IOCTL call flow

IOTCL call flow is described in Figure 10 and the ISP reference code is based on this implementation.

This flow will be expanded in the future.

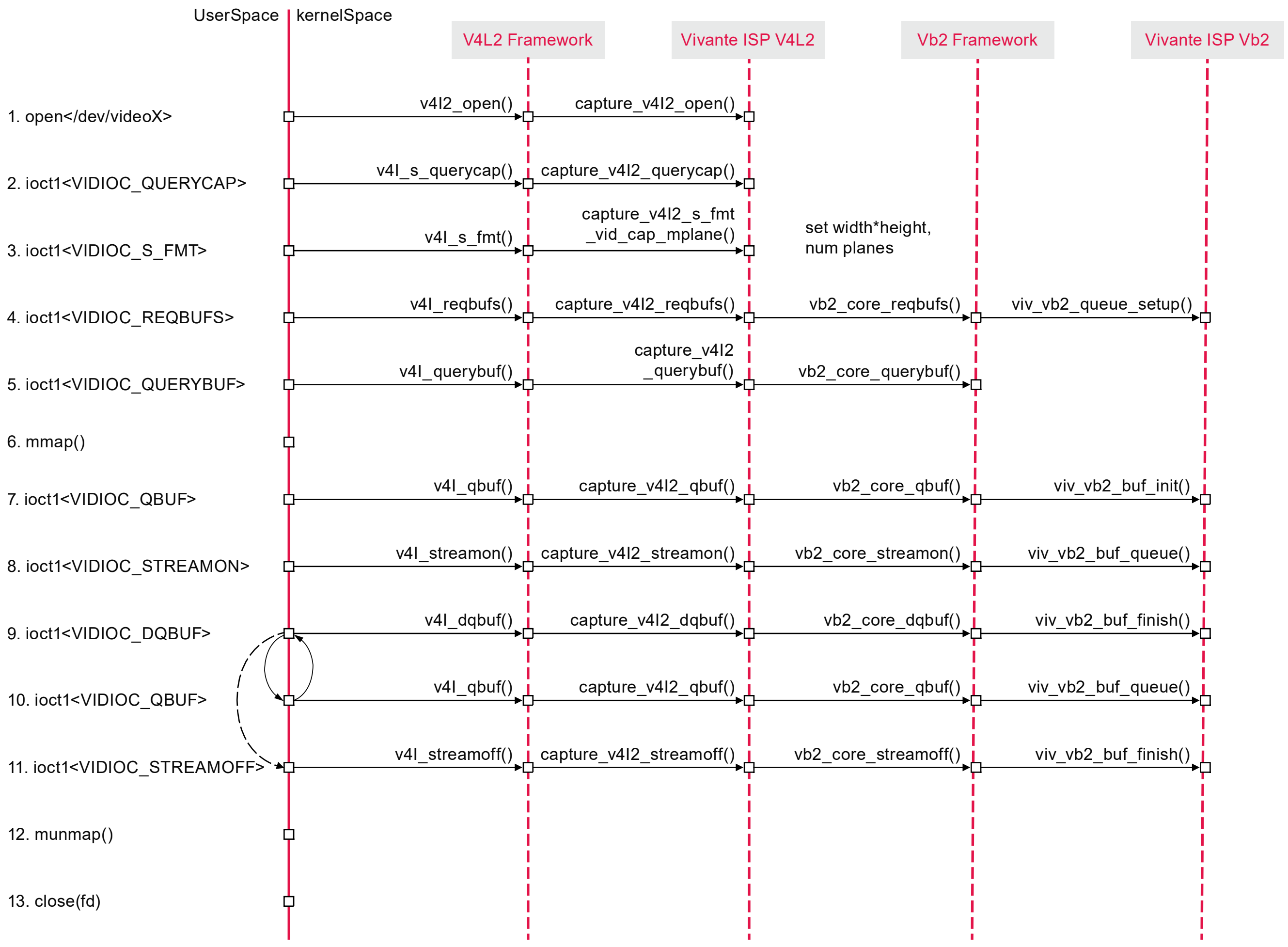


Figure 10. IOCTL call flow

3.2.3 Buffer API

A buffer contains data exchanged by the application and driver using memory mapping I/O. Only pointers to buffers are exchanged; the data itself is not copied. The primary intent of memory mapping is to map buffers in device memory into the address space of the application.

The V4L2 driver supports the following buffer IOCTLs:

- `VIDIOC_REQBUFS`
- `VIDIOC_QUERYBUF`
- `VIDIOC_QBUF`
- `VIDIOC_DQBUF`
- `VIDIOC_STREAMON`
- `VIDIOC_STREAMOFF`

In addition, the following functions are supported.

- `mmap()`
- `munmap()`

- `select()`
- `poll()`

3.2.3.1 Buffer IOCTL control words

- VIDIOC_REQBUFS

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/vidioc-reqbufs.html
- VIDIOC_QUERYBUF

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/vidioc-querybuf.html
- VIDIOC_QBUF

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/vidioc-qbuf.html
- VIDIOC_DQBUF

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/vidioc-qbuf.html
- VIDIOC_STREAMON

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/vidioc-streamon.html
- VIDIOC_STREAMOFF

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/vidioc-streamon.html

3.2.3.2 Buffer functions

- mmap

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/func-mmap.html
- munmap

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/func-munmap.html
- poll

  Link: https://www.kernel.org/doc/html/v5.10/userspace-api/media/v4l/func-poll.html

3.2.4 Event API

The V4L2 event interface provides a means for a user to get notified immediately on certain conditions taking place on a device.

To receive events, first the user must subscribe to an event using the `VIDIOC_SUBSCRIBE_EVENT` and the `VIDIOC_UNSUBSCRIBE_EVENT IOCTLs`. Once an event is subscribed, the events of subscribed types are de-queueable using the `VIDIOC_DQEVENT IOCTL`. Events may be unsubscribed using the `VIDIOC_UNSUBSCRIBE_EVENT IOCTL`. The information on de-queueable events is obtained by using `poll()` system calls on video devices. The V4L2 events use POLLPRI events on poll system calls.

The V4L2 driver supports the following event IOCTLs:

- `VIDIOC_SUBSCRIBE_EVENT`
- `VIDIOC_UNSUBSCRIBE_EVENT`
- `VIDIOC_DQEVENT`

In addition, the following function is supported.

- `poll()`

3.2.4.1 Event IOCTL control words

- VIDIOC_SUBSCRIBE_EVENT

Link: http://www.kernel.org/doc/html/v5.4/media/uapi/v4l/vidioc-subscribe-event.html

- VIDIOC_UNSUBSCRIBE_EVENT

  Link: http://www.kernel.org/doc/html/v5.4/media/uapi/v4l/vidioc-subscribe-event.html

- VIDIOC_DQEVENT

  Link: http://www.kernel.org/doc/html/v5.4/media/uapi/v4l/vidioc-dqevent.html

3.2.4.2 Event functions

- poll

  Link: http://www.kernel.org/doc/html/v5.4/media/uapi/v4l/func-poll.html

3.2.4.3 Private event

The private event is an extension based on `V4L2_EVENT_PRIVATE_START`. It defines ID of the private event source, defines event data struct `knl_v4l2_event_data` based on struct `v4l2_event.u.data[64]`.

Private event type:

- `KNL_VIVCAM_V4L2_EVENT_TYPE`

ID:

- `KNL_VIVCAM_NOTIFY`

Struct definition:

- Struct knl_v4l2_event_data, 64 bytes.

Table 9. Private event

Structure member	Type	Description
`command`	unsigned int	Extension based on `V4L2_CID_PRIVATE_BASE`
`status`	unsigned int	
`session_id`	unsigned int	
`stream_id`	unsigned int	
`nop1`	unsigned int	Reserved for future extensions
…	…	…
`nop12`	unsigned int	

3.2.5 Feature control API

The feature control API, uses JavaScript Object Notation (JSON) objects in user application threads and shares the objects directly with the daemon using share memory methods.

The ISP daemon sets ISPCore feature control words directly with the JSON parameters. In the user space and kernel space transfer, the Json::Value object is translated to a char string. Then, it is transferred between the user and kernel space as shown in Figure 11.

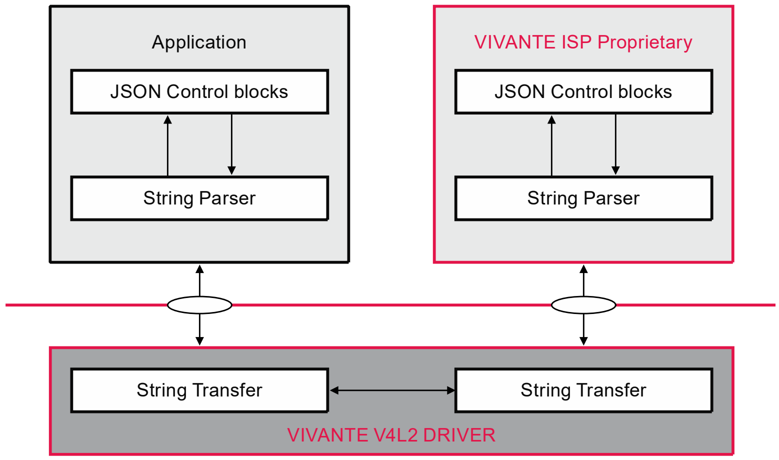


Figure 11. Feature control block diagram

3.2.5.1 String parser

The JSON format used for the APIs and the string transfer can be handled using open source code.

For example:

1. Json::Value to char string:

```
String Json::Value::toStyledString(Json::Value)
```

2. char string to Json::Value:

```
Json::CharReaderBuilder::parse(const char* beginDoc,
                                    const char* endDoc,
                                    Value& root, bool collectComments = true);
```

3.2.5.2 String transfer

All feature-related JSON-String entities are transferred using the following IOCTLs:

- `VIDIOC_G_EXT_CTRLS`

  Link: http://www.kernel.org/doc/html/v5.4/media/uapi/v4l/vidioc-g-ext-ctrls.html

- `VIDIOC_S_EXT_CTRLS`

  Link: http://www.kernel.org/doc/html/v5.4/media/uapi/v4l/vidioc-g-ext-ctrls.html

For a detailed example, refer to the code `appshell/vvext/vvext.cpp`.

The char string memory block exchange using the `v4l2_ext_control` struct, as shown in Table 10.

Table 10. v4l2_ext_control Structure

v4l2_ext_control structure member	Type	Description
`id`	`__u32`	V4L2 ISP SW feature control words
`size`	`__u32`	String length

Table continues on the next page...

Table 10. v4l2_ext_control Structure (continued)

v4l2_ext_control structure member	Type	Description
reserved2[1]	__u32	
value	union of __s32	
value64	union of __s64	
string	union of char *	String transfer pointer
p_u8	union of __u8 *	
p_u16	union of __u16 *	
p_u32	union of __u32 *	
ptr	union of void*	

3.2.5.3 Feature control words

Interface header file: `mediacontrol/include_api/ioctl_cmds.h`.

- IF_AE_G_CFG

  This macro definition is identical to the string “ae.g.cfg”.

  Description: Gets the configuration values for the Auto Exposure control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 11. Control words for IF_AE_G_CFG

Control Word	Description	Valid Values
mode	Configuration mode	1: Disabled evaluation 2: Fix evaluation 3: Adaptive evaluation
damp.over	Damping upper limit	[0.0 … 1.0]
damp.under	Damping lower limit	[0.0 … 1.0]
set.point	Set point	[0 … 255]
clm.tolerance	Calculation accuracy	[0 … 100]

- IF_AE_S_CFG

  This macro definition is identical to the string "ae.s.cfg".

  Description: Sets the configuration values for the Auto Exposure control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 12. Control words for IF_AE_S_CFG

Control Word	Description	Valid Values
`mode`	Configuration mode	1: Disabled evaluation 2: Fix evaluation 3: Adaptive evaluation
`damp.over`	Damping upper limit	[0.0 … 1.0]
`damp.under`	Damping lower limit	[0.0 … 1.0]
`set.point`	Set point	[0 … 255]
`clm.tolerance`	Calculation accuracy	[0 … 100]

- IF_AE_G_ECM

  This macro definition is identical to the string "ae.g.ecm".

  Description: Gets the ECM (Exposure Control Module) values for the Auto Exposure control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 13. Control words for IF_AE_G_ECM

Control word	Description	Valid Values
`flicker.period`	The flag of Auto Exposure flicker period	[0 … 2] — 0: Flicker Period off — 1: 100 Hz — 2: 120 Hz
`afps`	Auto FPS control value	true false

- IF_AE_S_ECM

  This macro definition is identical to the string "ae.s.ecm".

  Description: Sets the ECM (Exposure Control Module) values for the Auto Exposure control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 14. Control words for IF_AE_S_ECM

Control word	Description	Valid Values
`flicker.period`	The flag of Auto Exposure flicker period	[0 … 2]

Table continues on the next page...

Table 14. Control words for IF_AE_S_ECM (continued)

Control word	Description	Valid Values
		— 0: Flicker Period off — 1: 100 Hz — 2: 120 Hz
`afps`	Auto FPS control value	— true — false

- IF_AE_G_EN

  This macro definition is identical to the string "ae.g.en".

  Description: Gets the enabled/disabled state of the Auto Exposure control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 15. Control words for IF_AE_G_EN

Control word	Description	Valid Values
`enable`	The state of Auto Exposure	— `true` — `false`

- IF_AE_S_EN

  This macro definition is identical to the string "ae.s.en".

  Description: Sets the enabled/disabled state of the Auto Exposure control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 16. Control words for IF_AE_S_EN

Control word	Description	Valid Values
`enable`	Enable or disable Auto Exposure	— `true` — `false`

- IF_AE_RESET

  This macro definition is identical to the string "ae.reset".

  Description: Reset the Auto Exposure control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 17. Control words for IF_AE_RESET

Control word	Description	Valid Values
N/A	-	-

- IF_AF_G_CFG

  This macro definition is identical to the string "af.g.cfg".

  Description: Gets the configuration of the Auto Focus control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 18. Control words for IF_AF_G_CFG

Control word	Description	Valid Values
`algorithm`	Algorithm type	— 1: full range — 2: adaptive range — 3: hill climbing
`oneshot`	Trigger mode is one shot	— true — false

- IF_AF_S_CFG

  This macro definition is identical to the string "af.s.cfg".

  Description: Sets the configuration of the Auto Focus control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 19. Control words for IF_AF_S_CFG

Control word	Description	Valid Values
`algorithm`	Algorithm type	— 1: full range — 2: adaptive range — 3: hill climbing
`oneshot`	Trigger mode is one shot	— true — false

- IF_AF_G_EN

  This macro definition is identical to the string "af.g.en".

  Description: Gets the enabled/disabled state of the Auto Focus control.

  Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 20. Control words for IF_AF_G_EN

Control word	Description	Valid Values
`enable`	The state of the Auto Focus	— `true` — `false`

- IF_AF_S_EN

  This macro definition is identical to the string "af.s.en".

  Description: Sets the enabled/disabled state of the Auto Focus control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 21. Control words for IF_AF_S_EN

Control word	Description	Valid Values
`enable`	Enable or disable Auto Focus	— `true` — `false`

- IF_AWB_G_CFG

  This macro definition is identical to the string "awb.g.cfg".

  Description: Gets the configuration of the Auto White Balance control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 22. Control Words for IF_AWB_G_CFG

Control word	Description	Valid Values
`mode`	AWB mode	— 1: manual — 2: auto
`index`	The index of calibration data in the database	[0 … 32]
`damping`	Have damped data	— true — false

- IF_AWB_S_CFG

  This macro definition is identical to the string "awb.s.cfg".

  Description: Sets the mode and index of the Auto White Balance control.

  Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 23. Control Words for IF_AWB_S_CFG

Control word	Description	Valid Values
`mode`	AWB mode	— 1: manual — 2: auto
`index`	The index of calibration data in the database	[0 … 32]
`damping`	Damping data	— true — false

- IF_AWB_G_EN

  This macro definition is identical to the string "awb.g.en".

  Description: Gets the enabled/disabled state of the Auto White Balance control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 24. Control words for IF_AWB_G_EN

Control word	Description	Valid Values
`enable`	The state of the AWB control	— `true` — `false`

- IF_AWB_S_EN

  This macro definition is identical to the string "awb.s.en".

  Description: Sets the enabled/disabled state of the Auto White Balance control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 25. Control words for IF_AWB_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Auto White Balance	— `true` — `false`

- IF_AWB_RESET

  This macro definition is identical to the string "awb.reset".

  Description: Resets the Auto White Balance control.

  Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 26. Control words for IF_AWB_RESET

Control word	Description	Valid Values
N/A	-	-

- IF_AWB_S_GAIN

  This macro definition is identical to the string "awb.s.gain".

  Description: Sets gains of the Auto White Balance.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 27. Control words for IF_AWB_S_GAIN

Control word	Description	Valid Values
`red`	Red gain	[0.000, 3.999]
`green.r`	Gr gain	[0.000, 3.999]
`green.b`	Gb gain	[0.000, 3.999]
`blue`	Blue gain	[0.000, 3.999]

- IF_AWB_S_MEASWIN

  This macro definition is identical to the string "awb.s.measwin".

  Description: Sets measuring window of the Auto White Balance.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 28. Control words for IF_AWB_S_MEASWIN

Control word	Description	Valid Values
`left`	Measuring window left start position	*Sensor-specific*
`top`	Measuring window top start position	*Sensor-specific*
`width`	Measuring window width	*Sensor-specific*
`height`	Measuring window height	*Sensor-specific*

- IF_AVS_G_CFG

  This macro definition is identical to the string "avs.g.cfg".

  Description: Gets the configuration values for the Auto Video Stabilization control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 29. Control words for IF_AVS_G_CFG

Control word	Description	Valid Values
`use.params`	AVS use params	true false
`acceleration`	AVS has acceleration	[0.0 … 100.0]
`base.gain`	Base gain of AVS	[0.00 … 1.00]
`fall.off`	AVS has fallen off	[0.00 … 1.00]
`num.itp.points`	The number of ITP points	[1 … 65536]
`theta`	Theta	[0.0 … 1.0]

- IF_AVS_S_CFG

  This macro definition is identical to the string "avs.s.cfg".

  Description: Sets the configuration values for the Auto Video Stabilization control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 30. Control words IF_AVS_S_CFG

Control word	Description	Valid Values
`use.params`	AVS use params	true false
`acceleration`	AVS has acceleration	[0.0 … 100.0]
`base.gain`	Base gain of AVS	[0.00 … 1.00]
`fall.off`	AVS has fallen off	[0.00 … 1.00]
`num.itp.points`	The number of ITP points	[1 … 65536]
`theta`	Theta	[0.0 … 1.0]

- IF_AVS_G_EN

  This macro definition is identical to the string "avs.g.en".

  Description: Gets the enabled/disabled state of the Auto Video Stabilization control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 31. Control words for IF_AVS_G_EN

Control word	Description	Valid Values
`enable`	The state of the AVS	— true — false

- IF_AVS_S_EN

  This macro definition is identical to the string "avs.s.en".

  Description: Sets the enabled/disabled state of the Auto Video Stabilization control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 32. Control words for IF_AVS_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables AVS	— true — false

- IF_BLS_G_CFG

  This macro definition is identical to the string "bls.g.cfg".

  Description: Gets the configuration values for the Black Level Subtraction control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 33. Control words for IF_BLS_G_CFG

Control word	Description	Valid Values
`red`	The red data information	Sensor-specific
`green.r`	The Gr data information	Sensor-specific
`green.b`	The Gb data information	Sensor-specific
`blue`	The blue data information	Sensor-specific

- IF_BLS_S_CFG

  This macro definition is identical to the string "bls.s.cfg".

  Description: Sets the configuration values for the Black Level Subtraction control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 34. Control words for IF_BLS_S_CFG

Control word	Description	Valid Values
`red`	The red data information	Sensor-specific
`green.r`	The Gr data information	Sensor-specific
`green.b`	The Gb data information	Sensor-specific
`blue`	The blue data information	Sensor-specific

- IF_CAC_G_EN

  This macro definition is identical to the string "cac.g.en".

  Description: Gets the enabled/disabled state of the Chromatic Aberration Correction control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 35. Control words for IF_CAC_G_EN

Control word	Description	Valid Values
`enable`	The state of the Chromatic Aberration Correction	— true — false

- IF_CAC_S_EN

  This macro definition is identical to the string "cac.s.en".

  Description: Sets the enabled/disabled state of the Chromatic Aberration Correction control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 36. Control words for IF_CAC_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Chromatic Aberration Correction	— `true` — `false`

- IF_CNR_G_CFG

  This macro definition is identical to the string "cnr.g.cfg".

  Description: Gets the configuration values for the Chroma Noise Reduction control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 37. Control words for IF_CNR_G_CFG

Control Word	Description	Valid Values
`tc1`	The CNR threshold value of the Cb channel.	[0 … 32767]
`tc2`	The CNR threshold value of the Cr channel.	[0 … 32767]

- IF_CNR_S_CFG

  This macro definition is identical to the string "cnr.s.cfg".

  Description: Sets the configuration values for the Chroma Noise Reduction control.

  Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 38. Control words for IF_CNR_S_CFG

Control word	Description	Valid Values
`tc1`	The CNR threshold value of the Cb channel.	[0 … 32767]
`tc2`	The CNR threshold value of the Cr channel.	[0 … 32767]

- IF_CNR_G_EN

  This macro definition is identical to the string "cnr.s.en".

  Description:

  Gets the enabled/disabled state of the Chroma Noise Reduction control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 39. Control Words for IF_CNR_G_EN

Control Word	Description	Valid Values
`enable`	The state of the Chroma Noise Reduction control	— true — false

- IF_CNR_S_EN

  This macro definition is identical to the string "cnr.s.en".

  Description:

  Sets the enabled/disabled state of the Chroma Noise Reduction control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 40. Control Words for IF_CNR_S_EN

Control Word	Description	Valid Values
`enable`	Enables or disables Chroma Noise Reduction control	— true — false

- IF_CPROC_G_CFG

  This macro definition is identical to the string "cproc.g.cfg".

  Description: Gets the configuration values for the Color Processing control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 41. Control words for IF_CPROC_G_CFG

Control Word	Description	Valid Values
`brightness`	Brightness value	[-128 … 127] — Default: -15 — Greater than 1: increases brightness; — less than 1 decreases brightness.
`chroma.out`	CPROC chrominance pixel clipping range at output	— 1: CbCr_out clipping range [16 … 240] according to ITU-R BT.601 standard — 2: full UV_out clipping range [0 … 255]
`contrast`	Contrast value	[0 … 1.9921875] — Default: 1.1 — Greater than 1: increases contrast; — less than 1 decreases contrast.
`hue`	Hue value	[-90 … 89] — Default: 0 — Greater than 1: increases hue; — less than 1 decreases hue.
`luma.in`	CPROC luminance input range (offset processing)	— 1: Y_in range [64 … 940] according to ITU-R BT.601 standard; offset of 64 is subtracted from Y_in — 2: Y_in full range [0 … 1023]; no offset is subtracted from Y_in
`luma.out`	CPROC luminance output clipping range	— 1: Y_out clipping range [16 … 235]; offset of 16 is added to Y_out according to ITU-R BT.601 standard — 2: Y_out clipping range [0 … 255]; no offset is added to Y_out
`saturation`	Saturation value	[0 … 1.9921875] — Default: 1 — Greater than 1: increases saturation; — less than 1 decreases saturation.

- IF_CPROC_S_CFG

  This macro definition is identical to the string "cproc.s.cfg".

  Description: Sets the configuration values for the Color Processing control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 42. Control words for IF_CPROC_S_CFG

Control Word	Description	Valid Values
`brightness`	Brightness value	[-128 … 127] — Default: -15 — Greater than 1: increases brightness; — less than 1 decreases brightness.
`chroma.out`	CPROC chrominance pixel clipping range at output	— 1: CbCr_out clipping range [16 … 240] according to ITU-R BT.601 standard — 2: full UV_out clipping range [0 … 255]
`contrast`	Contrast value	[0 … 1.9921875] — Default: 1.1 — Greater than 1: increases contrast; — less than 1 decreases contrast.
`hue`	Hue value	[-90 … 89] — Default: 0 — Greater than 1: increases hue; — less than 1 decreases hue.
`luma.in`	CPROC luminance input range (offset processing)	— 1: Y_in range [64 … 940] according to ITU-R BT.601 standard; offset of 64 is subtracted from Y_in — 2: Y_in full range [0 … 1023]; no offset is subtracted from Y_in
`luma.out`	CPROC luminance output clipping range	— 1: Y_out clipping range [16 … 235]; offset of 16 is added to Y_out according to ITU-R BT.601 standard — 2: Y_out clipping range [0 … 255]; no offset is added to Y_out
`saturation`	Saturation value	[0 … 1.9921875] — Default: 1 — Greater than 1: increases saturation; — less than 1 decreases saturation.

- IF_CPROC_G_EN

  This macro definition is identical to the string "cproc.g.en".

  Description: Gets the enabled/disabled state of the Color Processing control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 43. Control words for IF_CPROC_G_EN

Control word	Description	Valid Values
`enable`	The state of the CPROC	— true — false

- IF_CPROC_S_EN

  This macro definition is identical to the string "cproc.s.en".

  Description: Sets the enabled/disabled state of the Color Processing control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 44. Control words for IF_CPROC_S_EN

Control word	Description	Valid Values
`enable`	Enable or disable CPROC	— true — false

- IF_DEMOSAIC_G_CFG

  This macro definition is identical to the string "dmsc.g.cfg".

  Description: Gets the configuration values for the Demosaic control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 45. Control words for IF_DEMOSAIC_G_CFG

Control word	Description	Valid Values
`mode`	Demosaic mode	1: normal 2: bypass
`threshold`	Demosaic threshold	[0..255]

- IF_DEMOSAIC_S_CFG

  This macro definition is identical to the string "dmsc.s.cfg".

  Description: Sets the configuration values for the Demosaic control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 46. Control words for IF_DEMOSAIC_S_CFG

Control word	Description	Valid Values
`mode`	Demosaic mode	— 1: normal — 2: bypass
`threshold`	Demosaic threshold	[0..255]

- IF_DEMOSAIC_G_EN

  This macro definition is identical to the string "demosaic.g.en".

  Description: Gets the enabled/disabled state of the Demosaic control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 47. Control words for IF_DEMOSAIC_G_EN

Control word	Description	Valid Values
`enable`	The state of the Demosaic control	— true — false

- IF_DEMOSAIC_S_EN

  This macro definition is identical to the string "demosaic.s.en".

  Description: Sets the enabled/disabled state of the Demosaic control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 48. Control words for IF_DEMOSAIC_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Demosaic	— true — false

- IF_DPCC_G_EN

  This macro definition is identical to the string "dpcc.g.en".

  Description: Gets the enabled/disabled state of the Defect Pixel Cluster Correction control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 49. Control words for IF_DPCC_G_EN

Control word	Description	Valid Values
`enable`	The state of the Defect Pixel Cluster Correction	— true — false

- IF_DPCC_S_EN

  This macro definition is identical to the string "dpcc.s.en".

  Description: Sets the enabled/disabled state of the Defect Pixel Cluster Correction control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 50. Control words for IF_DPCC_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Defect Pixel Cluster Correction	— true — false

- IF_DPF_G_CFG

  This macro definition is identical to the string "dpf.g.cfg".

  Description: Gets the configuration values for the De-noising Pre-Filter control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 51. Control words for IF_DPF_G_CFG

Control word	Description	Valid Values
`gradient`	Gradient value for dynamic strength calculation	[0 … 128]
`offset`	Offset value for dynamic strength calculation	[-128 … 128]
`min`	Upper bound for dynamic strength calculation	[0 … 128]
`div`	Division factor for dynamic strength calculation	[0 … 64]
`sigma.green`	Sigma value for green pixel	[1 … 255]
`sigma.red.blue`	Sigma value for red/blue pixel	[1 … 255]

- IF_DPF_S_CFG

  This macro definition is identical to the string "dpf.s.cfg".

  Description: Sets the configuration values for the De-noising Pre-Filter control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 52. Control words for IF_DPF_S_CFG

Control word	Description	Valid Values
`gradient`	Gradient value for dynamic strength calculation	[0 … 128]
`offset`	Offset value for dynamic strength calculation	[-128 … 128]
`min`	Upper bound for dynamic strength calculation	[0 … 128]
`div`	Division factor for dynamic strength calculation	[0 … 64]
`sigma.green`	Sigma value for green pixel	[1 … 255]
`sigma.red.blue`	Sigma value for red/blue pixel	[1 … 255]

- IF_DPF_G_EN

  This macro definition is identical to the string "dpf.g.en".

  Description: Gets the enabled/disabled state of the De-noising Pre-Filter control.

  Parameters:

  —

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 53. Control words for IF_DPF_G_EN

Control word	Description	Valid Values
`enable`	The state of the De-noising Pre-Filter	— true — false

- IF_DPF_S_EN

  This macro definition is identical to the string "dpf.s.en".

  Description: Sets the enabled/disabled state of the De-noising Pre-Filter control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 54. Control words for IF_DPF_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables De-noising Pre-Filter	— true — false

- IF_EC_G_CFG

  This macro definition is identical to the string "ec.g.cfg".

  Description: Gets the configuration values for the Exposure Control.

  Parameters:

  — `Json::Value &jRequest`

— `Json::Value &jResponse`

Table 55. Control words for IF_EC_G_CFG

Control Word	Description	Valid Values
`gain`	Exposure gain	sensor-specific
`gain.min`	Minimum gain	sensor-specific
`gain.max`	Maximum gain	sensor-specific
`time`	Exposure time	sensor-specific
`inte.min`	Minimum exposure time	sensor-specific
`inte.max`	Maximum exposure time	sensor-specific

- IF_EC_S_CFG

  This macro definition is identical to the string "ec.s.cfg".

  Description: Sets the configuration values for the Exposure Control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 56. Control words for IF_EC_S_CFG

Control word	Description	Valid Values
`gain`	Exposure gain	sensor-specific
`time`	Exposure time	sensor-specific

- IF_EE_G_CFG

  This macro definition is identical to the string "ee.g.cfg".

  Description: Gets the configuration values for the Edge Enhancement control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 57. Control words for IF_EE_G_CFG

Control Word	Description	Valid Values
`auto`	EE mode	true false
`config`	EE configure parameters	Edge gain: [0 … 65535] Strength: [0 … 128] UV gain: [0 … 65535] Y gain down: [0 … 65535] Y gain up: [0 … 65535]

- IF_EE_S_CFG

This macro definition is identical to the string "ee.s.cfg".

Description: Sets the configuration values for the Edge Enhancement control.

Parameters:

— `Json::Value &jRequest`

— `Json::Value &jResponse`

Table 58. Control words for IF_EE_S_CFG

Control Word	Description	Valid Values
`auto`	EE mode	true false
`config`	EE configure parameters	Edge gain: [0 … 65535] Strength: [0 … 128] UV gain: [0 … 65535] Y gain down: [0 … 65535] Y gain up: [0 … 65535]

- IF_EE_G_EN

  This macro definition is identical to the string "ee.g.en".

  Description: Gets the enabled/disabled state of the Edge Enhancement control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 59. Control words for IF_EE_G_EN

Control word	Description	Valid Values
`enable`	The state of the Edge Enhancement control	— true — false

- IF_EE_S_EN

  This macro definition is identical to the string "ee.s.en".

  Description: Sets the enabled/disabled state of the Edge Enhancement control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 60. Control words for IF_EE_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Edge Enhancement	— true — false

- IF_EE_RESET

  This macro definition is identical to the string "ee.reset".

  Description: Resets the Edge Enhancement control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 61. Control words for IF_EE_RESET

Control word	Description	Valid Values
N/A	-	-

- IF_EE_S_TBL

  This macro definition is identical to the string "ee.s.tbl".

  Description: Sets the EE control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 62. Control words for IF_EE_S_TBL

Control word	Description	Valid Values
`table`	EE table	description string

- IF_FILTER_G_CFG

  This macro definition is identical to the string "filter.g.cfg".

  Description: Gets the configuration values for the Filter control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 63. Control words for IF_FILTER_G_CFG

Control word	Description	Valid Values
`auto`	Auto control	true false
`denoise`	Denoise	[0..10]
`sharpen`	Sharpen	[0..10]

- IF_FILTER_S_CFG

  This macro definition is identical to the string "filter.s.cfg".

  Description: Sets the configuration values for the Filter control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 64. Control words for IF_FILTER_S_CFG

Control word	Description	Valid Values
`auto`	Auto control	true false
`denoise`	Denoise	[0..10]
`sharpen`	Sharpen	[0..10]

- IF_FILTER_G_EN

  This macro definition is identical to the string "filter.g.en".

  Description: Gets the enabled/disabled state of the Filter control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 65. Control words for IF_FILTER_G_EN

Control word	Description	Valid Values
`enable`	The state of the Filter control	true false

- IF_FILTER_S_EN

  This macro definition is identical to the string "filter.s.en".

  Description: Sets the enabled/disabled state of the Filter control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 66. Control words for IF_FILTER_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Filter	true false

- IF_FILTER_S_TBL

  This macro definition is identical to the string "filter.s.tbl".

  Description: Sets the Filter control table.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 67. Control words for IF_FILTER_S_TBL

Control word	Description	Valid Values
`table`	Filter table	description string

- IF_GC_G_CURVE

  This macro definition is identical to the string "gc.g.curve".

  Description: Gets the configuration values for the Gamma control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 68. Control words for IF_GC_G_CURVE

Control word	Description	Valid Values
`curve`	Gamma curve	[0 … 1023]

- IF_GC_S_CURVE

  This macro definition is identical to the string "gc.s.curve".

  Description: Sets the configuration values for the Gamma Control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 69. Control words for IF_GC_S_CURVE

Control word	Description	Valid Values
`curve`	Gamma curve	[0 … 1023]

- IF_GC_G_CFG

  This macro definition is identical to the string "gc.g.cfg".

  Description: Gets the configuration values for the Gamma control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 70. Control words for IF_GC_G_CFG

Control word	Description	Valid Values
`gc.mode`	The mode of the Gamma Control.	— 1: logarithmic mode — 2: equidistant mode

- IF_GC_S_CFG

  This macro definition is identical to the string "gc.s.cfg".

  Description: Sets the configuration values for the Gamma control.

Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 71. Control words for IF_GC_G_CFG

Control word	Description	Valid Values
`gc.mode`	The mode of the Gamma Control.	— 1: logarithmic mode — 2: equidistant mode

- IF_GC_G_EN

  This macro definition is identical to the string "gc.g.en".

  Description: Gets the enabled/disabled state of the Gamma Control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 72. Control words for IF_GC_G_EN

Control word	Description	Valid Values
`enable`	The state of the Gamma Control	— true — false

- IF_GC_S_EN

  This macro definition is identical to the string "gc.s.en".

  Description: Sets the enabled/disabled state of the Gamma Control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 73. Control words for IF_GC_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Gamma Control	— true — false

- IF_HDR_G_CFG

  This macro definition is identical to the string "hdr.g.cfg".

  Description: Gets the configuration of the High Dynamic Range control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 74. Control words for IF_HDR_G_CFG

Control word	Description	Valid Values
`extension.bit`	Extension bit	[0..4]
`exposure.ratio`	Exposure ratio	[0..16]

- IF_HDR_S_CFG

  This macro definition is identical to the string "hdr.s.cfg".

  Description: Sets the configuration of the High Dynamic Range control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 75. Control words for IF_HDR_S_CFG

Control Word	Description	Valid Values
`extension.bit`	Extension bit	[0..4]
`exposure.ratio`	Exposure ratio	[0..16]

- IF_HDR_G_EN

  This macro definition is identical to the string "hdr.g.en".

  Description: Gets the enabled/disabled state of the High Dynamic Range control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 76. Control words for IF_HDR_G_EN

Control word	Description	Valid Values
`enable`	The state of High Dynamic Range	— true — false

- IF_HDR_S_EN

  This macro definition is identical to the string "hdr.s.en".

  Description: Sets the enabled/disabled state of the High Dynamic Range control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 77. Control words for IF_HDR_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables High Dynamic Range	— true — false

- IF_HDR_RESET

  This macro definition is identical to the string "hdr.reset".

  Description: Resets the High Dynamic Range control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 78. Control words for IF_HDR_RESET

Control word	Description	Valid Values
N/A	-	-

- IF_IE_G_CFG

  This macro definition is identical to the string "ie.g.cfg".

  Description: Gets the configuration values for the Image Effects control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 79. Control words for IF_IE_G_CFG

Control Word	Description	Valid Values
`mode`	IE working modes	1: Set a fixed chrominance of 128 (neutral gray) 2: Luminance and chrominance data is being inverted 3: Chrominance is changed to produce a historical like brownish image color 4: Converting picture to grayscale while maintaining one color component 5: Edge detection, looks like a relief made of metal 6: Edge detection, looks like a pencil drawing 7: Edge detection, looks like a sharper drawing
`range`	Image Effects configuration range	1: pixel value range according to BT.601 2: YCbCr full range [0 … 255]
`config`	Image Effects configuration	---
`tint.cb`	Sepia Tint Cb of sepia mode	[0 … 255]
`tint.cr`	Sepia Tint Cr of sepia mode	[0 … 255]
`selection`	Color selection of color mode	1: red, green, and blue 2: blue 3: green 4: green and blue

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Table 79. Control words for IF_IE_G_CFG (continued)

Control Word	Description	Valid Values
		5: red 6: red and blue 7: red and green
`threshold`	Color threshold of color mode	[0 … 255]
`emboss:coeff`	Coefficient of emboss mode	[-128 … 127]
`sketch:coeff`	Coefficient of sketch mode	[-128 … 127]
`sharpen:factor`	Factor of sharpen mode	[0 … 255]
`sharpen:threshold`	Threshold of sharpen mode	[0 … 255]
`sharpen:coeff`	Coefficient of sharpen mode	[-128 … 127]

- IF_IE_S_CFG

  This macro definition is identical to the string "ie.s.cfg".

  Description: Sets the configuration values for the Image Effects control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 80. Control words for IF_IE_S_CFG

Control Word	Description	Valid Values
`mode`	IE working modes	1: Set a fixed chrominance of 128 (neutral gray) 2: Luminance and chrominance data is being inverted 3: Chrominance is changed to produce a historical like brownish image color 4: Converting picture to grayscale while maintaining one color component 5: Edge detection, looks like a relief made of metal 6: Edge detection, looks like a pencil drawing 7: Edge detection, looks like a sharper drawing
`range`	Image Effects configuration range	1: pixel value range according to BT.601 2: YCbCr full range [0 … 255]
`config`	Image Effects configuration	---
`tint.cb`	Sepia Tint Cb of sepia mode	[0 … 255]
`tint.cr`	Sepia Tint Cr of sepia mode	[0 … 255]
`selection`	Color selection of color mode	1: red, green, and blue 2: blue

Table continues on the next page...

Table 80. Control words for IF_IE_S_CFG (continued)

Control Word	Description	Valid Values
		3: green 4: green and blue 5: red 6: red and blue 7: red and green
`threshold`	Color threshold of color mode	[0 … 255]
`emboss:coeff`	Coefficient of emboss mode	[-128 … 127]
`sketch:coeff`	Coefficient of sketch mode	[-128 … 127]
`sharpen:factor`	Factor of sharpen mode	[0 … 255]
`sharpen:threshold`	Threshold of sharpen mode	[0 … 255]
`sharpen:coeff`	Coefficient of sharpen mode	[-128 … 127]

- IF_IE_G_EN

  This macro definition is identical to the string "ie.g.en".

  Description: Gets the enabled/disabled state of the Image Effects control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 81. Control words for IF_IE_G_EN

Control word	Description	Valid Values
`enable`	The state of the Image Effects control	— true — false

- IF_IE_S_EN

  This macro definition is identical to the string "ie.s.en".

  Description: Sets the enabled/disabled state of the Image Effects control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 82. Control words for IF_IE_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Image Effects	— true — false

- IF_LSC_G_EN

This macro definition is identical to the string "lsc.g.en".

Description: Gets the enabled/disabled state of the Lens Shade Correction control.

Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 83. Control words for IF_LSC_G_EN

Control word	Description	Valid Values
`enable`	The state of Lens Shade Correction	— true — false

- IF_LSC_S_EN

  This macro definition is identical to the string "lsc.s.en".

  Description: Sets the enabled/disabled state of the Lens Shade Correction control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 84. Control words for IF_LSC_S_EN

Control word	Description	Valid Values
`enable`	Enables or disables Lens Shade Correction	— true — false

- IF_2DNR_G_CFG

  This macro definition is identical to the string "2dnr.g.cfg".

  Description: Gets the configuration values for the 2DNR control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 85. Control words for IF_2DNR_G_CFG

Control Word	Description	Valid Values
`generation`	2DNR generation	[0 … 2]
`auto`	3DNR running mode	true false
`denoise.pregama.strength`	Denoise pregame strength	[0, 1]
`denoise.strength`	Configuration strength	[0 … 100]
`sigma`	Sigma strength	[0 … 100]

- IF_2DNR_S_CFG

This macro definition is identical to the string "2dnr.s.cfg".

Description: Sets the configuration values for the 2DNR control.

Parameters:

— `Json::Value &jRequest`

— `Json::Value &jResponse`

Table 86. Control words for IF_2DNR_S_CFG

Control Word	Description	Valid Values
`generation`	2DNR generation	[0 … 2]
`auto`	3DNR running mode	true false
`denoise.pregama.strength`	Denoise pregame strength	[0, 1]
`denoise.strength`	Configuration strength	[0 … 100]
`sigma`	Sigma strength	[0 … 100]

- IF_2DNR_G_EN

  This macro definition is identical to the string "2dnr.g.en".

  Description: Gets the enabled/disabled state of the 2DNR control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 87. Control words for IF_2DNR_G_EN

Control Word	Description	Valid Values
`enable`	The state of 2DNR	true false
`generation`	2DNR generation	[0 … 2]

- IF_2DNR_S_EN

  This macro definition is identical to the string "2dnr.s.en".

  Description: Sets the enabled/disabled state of the 2DNR control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 88. Control words for IF_2DNR_S_EN

Control Word	Description	Valid Values
`enable`	Enables or disables 2DNR	true false
`generation`	2DNR generation	[0 … 2]

- IF_2DNR_RESET

  This macro definition is identical to the string "2dnr.reset".

  Description: Resets the 2DNR control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 89. Control words for IF_2DNR_RESET

Control word	Description	Valid Values
`generation`	NR2D generation	[0 … 2]

- IF_2DNR_S_TBL

  This macro definition is identical to the string "2dnr.s.tbl".

  Description: Resets the 2DNR control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 90. Control words for IF_2DNR_S_TBL

Control word	Description	Valid Values
`table`	2DNR table	description string

- IF_3DNR_G_CFG

  This macro definition is identical to the string "3dnr.g.cfg".

  Description: Gets the configuration values for the 3DNR control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 91. Control words for IF_3DNR_G_CFG

Control Word	Description	Valid Values
`generation`	3DNR generation	[0 … 2]
`auto`	3DNR running mode	true false
`strength`	3DNR strength	[0 … 128]
`delta.factor`	Delta factor value	[0 … 1023]
`motion.factor`	motion factor value	[0 … 1000000]

- IF_3DNR_S_CFG

  This macro definition is identical to the string "3dnr.s.cfg".

  Description: Sets the configuration values for the 3DNR control.

Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 92. Control words for IF_3DNR_S_CFG

Control Word	Description	Valid Values
`generation`	3DNR generation	[0 … 2]
`auto`	3DNR running mode	true false
`strength`	3DNR strength	[0 … 128]
`delta.factor`	Delta factor value	[0 … 1023]
`motion.factor`	motion factor value	[0 … 1000000]

- IF_3DNR_G_EN

  This macro definition is identical to the string "3dnr.g.en".

  Description: Gets the enabled/disabled state of the 3DNR control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 93. Control words for IF_3DNR_G_EN

Control Word	Description	Valid Values
`enable`	The state of 3DNR	true false
`generation`	3DNR generation	[0 … 2]

- IF_3DNR_S_EN

  This macro definition is identical to the string "3dnr.s.en".

  Description: Sets the enabled/disabled state of the 3DNR control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 94. Control words for IF_3DNR_S_EN

Control Word	Description	Valid Values
`enable`	Enable or disable 3DNR	true false
`generation`	3DNR generation	[0 … 2]

- IF_3DNR_RESET

  This macro definition is identical to the string "3dnr.reset".

Description: Resets the 3DNR control.

Parameters:

— `Json::Value &jRequest`

— `Json::Value &jResponse`

Table 95. Control words for IF_3DNR_RESET

Control word	Description	Valid Values
`generation`	NR3D generation	[0 … 2]

- IF_3DNR_S_TBL

  This macro definition is identical to the string "3dnr.reset".

  Description: Resets the 3DNR control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 96. Control words for IF_3DNR_S_TBL

Control word	Description	Valid Values
`table`	3DNR table	description string
`generation`	3DNR generation	[0 … 2]

- IF_WDR_G_CFG

  This macro definition is identical to the string "wdr.g.cfg".

  Description: Gets the configuration values for the WDR control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 97. Control words for IF_WDR_G_CFG

Control Word	Description	Valid Values
`generation`	WDR generation	[0 … 2]
`curve`	WDR1 curve value	[tone mapping curve values]
`auto`	WDR3 running mode	true false
`strength`	WDR2 or WDR3 strength	[0, 128]
`gain.max`	WDR3 gain max	[0, 128]
`strength.global`	WDR3 global strength	[0, 128]

- IF_WDR_S_CFG

  This macro definition is identical to the string "wdr.s.cfg".

  Description: Sets the configuration values for the WDR control.

Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 98. Control words for IF_WDR_S_CFG

Control Word	Description	Valid Values
`generation`	WDR generation	[0 … 2]
`curve`	WDR1 curve value	[tone mapping curve values]
`auto`	WDR3 running mode	true false
`strength`	WDR2 or WDR3 strength	[0, 128]
`gain.max`	WDR3 gain max	[0, 128]
`strength.global`	WDR3 global strength	[0, 128]

- IF_WDR_G_EN

  This macro definition is identical to the string "wdr.g.en".

  Description: Gets the enabled/disabled state of the WDR control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 99. Control words for IF_WDR_G_EN

Control Word	Description	Valid Values
`enable`	The state of WDR	true false
`generation`	WDR generation	[0 … 2]

- IF_WDR_S_EN

  This macro definition is identical to the string "wdr.s.en".

  Description: Sets the enabled/disabled state of the WDR control.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 100. Control words for IF_WDR_S_EN

Control Word	Description	Valid Values
`enable`	Enables or disables WDR	true false
`generation`	WDR generation	[0 … 2]

- IF_WDR_RESET

This macro definition is identical to the string "wdr.reset".

Description: Resets the WDR control.

Parameters:

— `Json::Value &jRequest`

— `Json::Value &jResponse`

Table 101. Control words for IF_WDR_RESET

Control word	Description	Valid Values
`generation`	WDR generation	[0 … 2]

- IF_WDR_S_TBL

  This macro definition is identical to the string "wdr.s.tb".

  Description: Sets the table of the WDR control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 102. Control words for IF_WDR_S_TBL

Control word	Description	Valid Values
`table`	WDR table	description string
`generation`	WDR generation	[0 … 2]

- IF_WB_G_CFG

  Description: Gets the configuration values for the WB control.

  This macro definition is identical to the string "wb.g.cfg".

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 103. Control words for IF_WB_G_CFG

Control Word	Description	Valid Values
`matrix`	Matrix	[<matrix values>]
`offset`	Offset	[-2048, 2047]
`red`	Cc offset red	[-2048, 2047]
`green`	Cc offset green	[-2048, 2047]
`blue`	Cc offset blue	[-2048, 2047]
`red`	WB gains red	[0.000, 3.999]
`green.r`	WB gains green.r	[0.000, 3.999]
`green.b`	WB gains green.b	[0.000, 3.999]

Table continues on the next page...

Table 103. Control words for IF_WB_G_CFG (continued)

Control Word	Description	Valid Values
`blue`	WB gains blue	[0.000, 3.999]
`wb.gains`	WB gains	[0.000, 3.999]

- IF_WB_S_CFG

  This macro definition is identical to the string "wb.s.cfg".

  Description: Sets the configuration values for the WB control.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 104. Control words for IF_WB_S_CFG

Control Word	Description	Valid Values
`matrix`	Matrix	[<matrix values>]
`offset`	Offset	[-2048, 2047]
`red`	Cc offset red	[-2048, 2047]
`green`	Cc offset green	[-2048, 2047]
`blue`	Cc offset blue	[-2048, 2047]
`red`	WB gains red	[0.000, 3.999]
`green.r`	WB gains green.r	[0.000, 3.999]
`green.b`	WB gains green.b	[0.000, 3.999]
`blue`	WB gains blue	[0.000, 3.999]
`wb.gains`	WB gains	[0.000, 3.999]

3.2.5.4 Dewarp control words

NOTE

Requires hardware with dewarp capability.

- IF_DWE_S_PARAMS

  This macro definition is identical to the string "dwe.s.params".

  Description: Sets the dewarp parameters: input format, output format, ROI, scale, split, dewarp type, and so on.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 105. Control Words for IF_DWE_S_PARAMS

Control Word	Description	Valid Values
`dwe`	Get the dewarp node	node description string

Table continues on the next page...

Table 105. Control Words for IF_DWE_S_PARAMS (continued)

Control Word	Description	Valid Values
`mode`	Dewarp type	1: lens distortion 2: 'fisheye expand' 4: split screen 8: 'fisheye dewarp'
`hflip`	Set horizontal flip true or false	— true — false
`vflip`	Set vertical flip true or false	— true — false
`bypass`	Bypass dewarp true or false	— true — false
`mat`	Camera matrix [0-8] Distortion coefficient [9-16]	Need calibration

- IF_DWE_G_PARAMS

  This macro definition is identical to the string "dwe.g.params".

  Description: Gets the Dewarp parameters: input format, output format, ROI, scale, split, dewarp type, and so on.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 106. Control words for IF_DWE_G_PARAMS

Control Word	Description	Valid Values
`dwe`	Get the dewarp node	node description string
`mode`	Dewarp type	1: lens distortion 2: 'fisheye expand' 4: split screen 8: `fisheye dewarp`
`hflip`	Set horizontal flip true or false	— true — false
`vflip`	Set vertical flip true or false	— true — false
`bypass`	Bypass dewarp true or false	— true — false

Table continues on the next page...

Table 106. Control words for IF_DWE_G_PARAMS (continued)

Control Word	Description	Valid Values
`mat`	Camera matrix [0~8] Distortion coefficient [9~16]	Need calibration

- IF_DWE_S_HFLIP

  This macro definition is identical to the string "dwe.s.hflip".

  Description: Sets the image horizontal flip parameters.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 107. Control words for IF_DWE_S_HFLIP

Control Word	Description	Valid Values
`dwe`	Get the dewarp node	node description string
`hflip`	Set vertical flip	— true — false

- IF_DWE_S_VFLIP

  This macro definition is identical to the string "dwe.s.vflip".

  Description: Sets the image vertical flip parameters.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 108. Control words for IF_DWE_S_VFLIP

Control Word	Description	Valid Values
`dwe`	Get the dewarp node	node description string
`vflip`	Set horizontal flip	— true — false

- IF_DWE_S_BYPASS

  This macro definition is identical to the string "dwe.s.bypass".

  Description: Sets the Dewarp bypass true or false.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 109. Control words for IF_DWE_S_BYPASS

Control word	Description	Valid Values
`dwe`	Get the dewarp node	node description string
`bypass`	Bypass dewarp true or false	— true — false

- IF_DWE_S_MODE

  This macro definition is identical to the string "dwe.s.mode".

  Description: Sets the Dewarp mode index.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 110. Control words for IF_DWE_S_MODE

Control word	Description	Valid Values
`mode`	Sensor mode index	Sensor-specific
`dwe`	Get the dewarp node	— true — false

- IF_DWE_S_MAT

  This macro definition is identical to the string "dwe.s.mat".

  Description: Sets the camera matrix and distortion coefficient.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 111. Control words for IF_DWE_S_MAT

Control word	Description	Valid Values
`dwe`	Get the dewarp node	node description string
`mat`	Camera matrix [0-8] Distortion coefficient [9-16]	Need calibration

- IF_DWE_S_TYPE

  This macro definition is identical to the string "dwe.s.type".

  Description: Sets the Dewarp type.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 112. Control words for IF_DWE_S_TYPE

Control word	Description	Valid Values
`type`	Dewarp type	`1`: lens distortion `2`: 'fisheye expand' `4`: split screen `8`: 'fisheye dewarp'
`dwe`	Get the dewarp node	node description string

- VIV_V4L_DWE_SET_CROP

  Description: Crops the image.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 113. Control words for VIV_V4L_DWE_SET_CROP

Control Word	Description	Valid Values
`crop`	Get the crop node	node description string
`start_x`	The starting position of the X-axis	Sensor-specific
`start_y`	The starting position of the Y-axis	Sensor-specific
`width`	Crop width	Sensor-specific
`height`	Crop height	Sensor-specific

- VIV_V4L_DWE_SET_SCALE

  Description: Scales the image.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 114. Control words for VIV_V4L_DWE_SET_SCALE

Control Word	Description	Valid Values
`scale`	Get the scale node	node description string
`start_x`	The starting position of the X-axis	Sensor-specific
`start_y`	The starting position of the Y-axis	Sensor-specific
`width`	Scale width	Sensor-specific
`height`	Scale height	Sensor-specific

3.2.5.5 Sensor Control Words

- IF_SENSOR_QUERY

  This macro definition is identical to the string "sensor.query".

  Description: Queries sensor information.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 115. Control words for Sensor Control Words

Control Word	Description	Valid Values
`current`	Sensor current mode	Sensor-specific
`default`	Sensor default mode	Sensor-specific
`index`	Sensor index	Sensor-specific
`width`	Resolution width	Sensor-specific
`height`	Resolution height	Sensor-specific
`fps`	Sensor support maximum frame rate	Sensor-specific
`hdr_mode`	The mode corresponds to the sensor index	Sensor-specific
`bit_width`	Sensor support bit width	Sensor-specific
`bayer_pattern`	Sensor support Bayer pattern	Sensor-specific
`stitching_mode`	Sensor support stitching mode	Sensor-specific

- IF_SENSOR_G_MODE

  This macro definition is identical to the string "sensor.g.mode".

  Description: Gets sensor current mode.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 116. Control words for IF_SENSOR_G_MODE

Control word	Description	Valid Values
`mode`	Sensor current index	Sensor-specific

- IF_SENSOR_S_MODE

  This macro definition is identical to the string "sensor.s.mode".

  Description: Sets sensor mode.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 117. Control words for IF_SENSOR_S_MODE

Control word	Description	Valid Values
`mode`	Sensor mode index	Sensor-specific
`CalibXmlName`	Calibration file name	Sensor-specific

- IF_SENSOR_G_RESW

  This macro definition is identical to the string "sensor.g.resw".

  Description: Gets the sensor resolution width.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 118. Control words for IF_SENSOR_G_RESW

Control word	Description	Valid Values
`resw`	Resolution width	Sensor-specific

- IF_SENSOR_G_RESH

  This macro definition is identical to the string "sensor.g.resh".

  Description: Gets the sensor resolution height.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 119. Control words for IF_SENSOR_G_RESH

Control word	Description	Valid Values
`resh`	Resolution height	Sensor-specific

- IF_SENSOR_G_REG

  This macro definition is identical to the string "sensor.g.reg".

  Description: Gets the sensor register value.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 120. Control words for IF_SENSOR_G_REG

Control word	Description	Valid Values
`value`	Register value	Sensor-specific
`address`	Register address	Sensor-specific

- IF_SENSOR_S_REG

  This macro definition is identical to the string "sensor.s.reg".

  Description: Sets the sensor register value.

  Parameters:

— `Json::Value &jRequest`

— `Json::Value &jResponse`

Table 121. Control words for IF_SENSOR_S_REG

Control word	Description	Valid Values
`value`	Register value	Sensor-specific
`address`	Register address	Sensor-specific

- IF_S_FPS

  This macro definition is identical to the string "s.fps".

  Description: Sets the sensor frame rate.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 122. Control words for IF_S_FPS

Control word	Description	Valid Values
`fps`	Sensor frame rate	Sensor-specific

- IF_SENSOR_LIB_PRELOAD

  This macro definition is identical to the string "sensor.lib.preload".

  Description: Loads the sensor calibration file.

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 123. Control words for IF_SENSOR_LIB_PRELOAD

Control word	Description	Valid Values
N/A	-	-

- IF_SENSOR_G_SEC
- This macro definition is identical to the string "sensor.g.sec".

  Description: Get sensor start exposure (IntegrationTime x Gain).

  Parameters:

  — `Json::Value &jRequest`

  — `Json::Value &jResponse`

Table 124. Control words for IF_SENSOR_G_SEC

Control Word	Description	Valid Values
`exposure`	AE start exposure = IntegrationTime x Gain	Float value

- IF_SENSOR_S_SEC

  This macro definition is identical to the string "sensor.s.sec".

NOTE

Calling this function is only valid before the stream on.

Description: Sets sensor start exposure (IntegrationTime x Gain).

Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 125. Control words for IF_SENSOR_S_SEC

Control Word	Description	Valid Values
`exposure`	AE start exposure = IntegrationTime x Gain	Float value

- IF_SENSOR_S_TESTPAT

  This macro definition is identical to the string "sensor.s.testpat".

  Description: Sets sensor test pattern.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 126. Control words for IF_SENSOR_S_TESTPAT

Control Word	Description	Valid Values
`test.pattern`	Sensor test pattern mode	0: normal mode others: test pattern mode value

3.2.5.6 Pipeline Control Words

- IF_PIPELINE_S_WARM_UP

  This macro definition is identical to the string "pipeline.s.warm.up".

  Description: Warms up pipeline.

  Parameters:

  - `Json::Value &jRequest`
  - `Json::Value &jResponse`

Table 127. Control words for IF_PIPELINE_S_WARM_UP

Control Word	Description	Valid Values
N/A	-	-

- IF_PIPELINE_S_SMP_MODE

  This macro definition is identical to the string "pipeline.s.smp.mode".

  Description: Reserved for later use.

- IF_PIPELINE_S_DWE_ONOFF

  This macro definition is identical to the string "pipeline.s.dwe.onoff".

  Description: Enables/disables DEWARP.

Parameters:

- `Json::Value &jRequest`
- `Json::Value &jResponse`

Table 128. Control words for IF_PIPELINE_S_DWE_ONOFF

Control Word	Description	Valid Values
enable	Enable or disable dewarp.	true false

- IF_PIPELINE_S_TESTPAT

  This macro definition is identical to the string "pipeline.s.testpat".

  Description: Reserved for later use.

- IF_PIPELINE_S_RES_IS_OUT

  This macro definition is identical to the string "pipeline.s.res.is.out".

  Description: Reserved for later use.

- IF_PIPELINE_S_RES_MP_OUT

  This macro definition is identical to the string "pipeline.s.res.mp.out".

  Description: Reserved for later use.

- IF_PIPELINE_S_MP_FMT

  This macro definition is identical to the string "pipeline.s.mp.fmt".

  Description: Reserved for later use.

- IF_PIPELINE_QUERY

  This macro definition is identical to the string "pipeline.query".

  Description: Reserved for later use.

- IF_PIPELINE_CFG_STATUS

  This macro definition is identical to the string "pipeline.cfg.status".

  Description: Reserved for later use.

3.3 ISP software V4L2 programming overview

3.3.1 General concept

The high-level diagram of the ISP V4L2 software stack is shown in Figure 12.

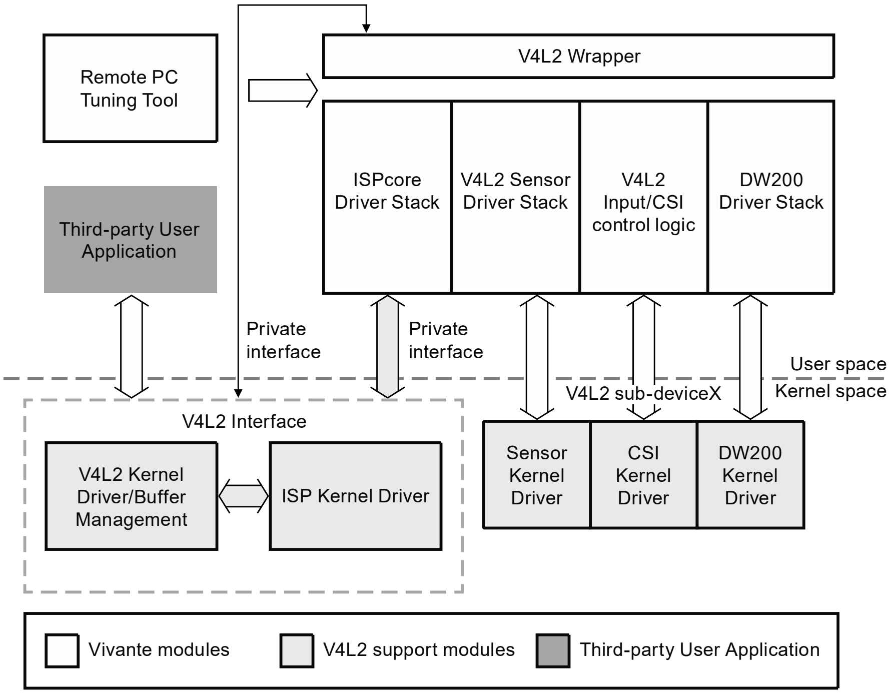

Figure 12. ISP software V4L2 stack

3.3.2 V4L2 kernel driver block diagram

ISP provides some device nodes in its file structure. Customers can operate the corresponding device through the appropriate device node(s).

Table 129. ISP device nodes

Device node/driver	Description
`/dev/mediax`	Enumerate video devices and subdevices.
`/dev/videox`	Manage stream related operations and events, such as enqueue/dequeue buffers and enqueue/dequeue events
`/dev/v4l2-subdevx`	Manage buffers, and Control camera relevant hardware, such as MIPI/Sensor
`/dev/xx`	Private interface control and dispatch the commands, events, and so on.
V4L2 kernel driver	Register the `V4L2_device` and `video_device` and implement the operational functions in the `video_device and vb2_queue`
ISP kernel driver	ISP kernel driver, implements read/write registers, and so on.

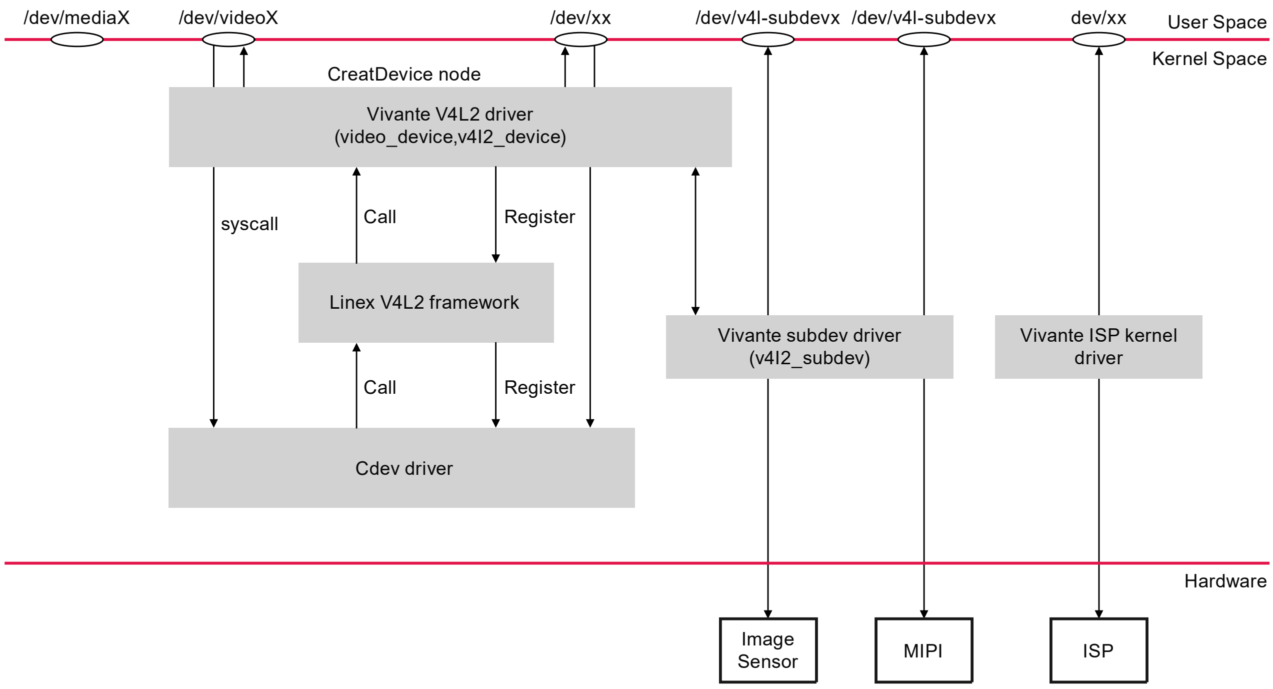

Figure 13. V4L2 kernel driver block diagram

3.3.3 V4L2 third-party user application and ISP stack communication

The V4L2 third-party user application communicates directly with the kernel with V4L2 standard control words and V4L2 extension control commands. All the user application controls pass to the kernel space to the V4L2 kernel driver.

The V4L2 kernel driver handles the API commands and requests from the V4L2 user application. It communicates to the ISP software stack and delivers image buffers to the V4L2 user application.

Submodules that handle the event and buffer:

- Event Queue: send/get events to/from ISP proprietary software.
- Buffer Queue: manages the vb2 buffer.

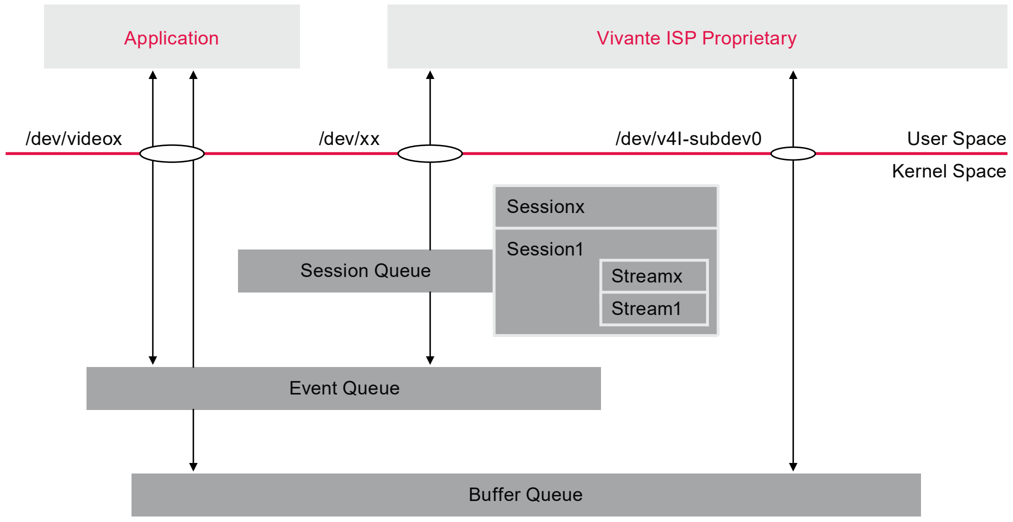

Figure 14. User application communication to ISP proprietary software stack

3.3.4 ISP V4L2 buffer management

There are three memory types as described in Table 130 and Figure 15.

Table 130. Memory types and buffer allocation

Memory type	Buffer allocation	Behavior
USERPTR	user space	User space and kernel space share the memory by buffer pointer
MMAP	kernel space	User space calls mmap to get pointer from kernel space
DMABUF	kernel space	User space gets the buffers using a file descriptor

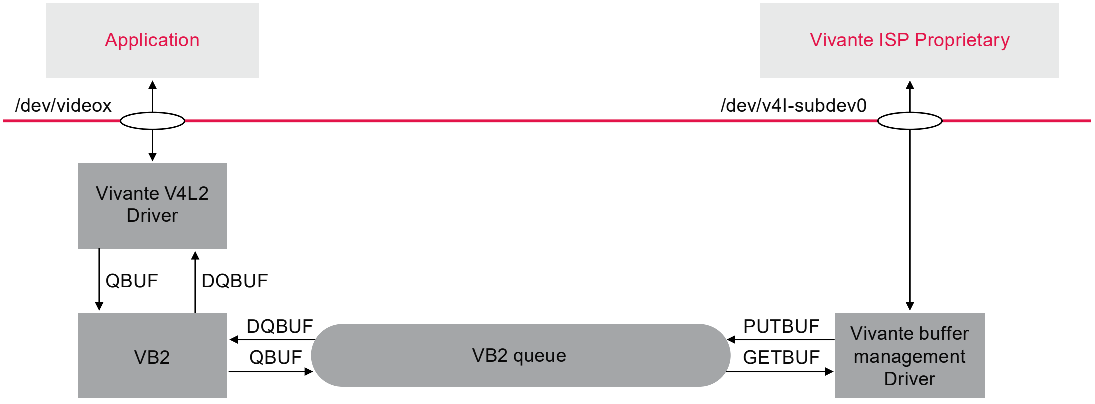

Figure 15. ISP V4L2 buffer management

NOTE

USERPTR mode is not supported.

3.3.5 ISP proprietary software stack

The camera manager receives messages for the kernel and dispatches these events to the corresponding submodule for processing.

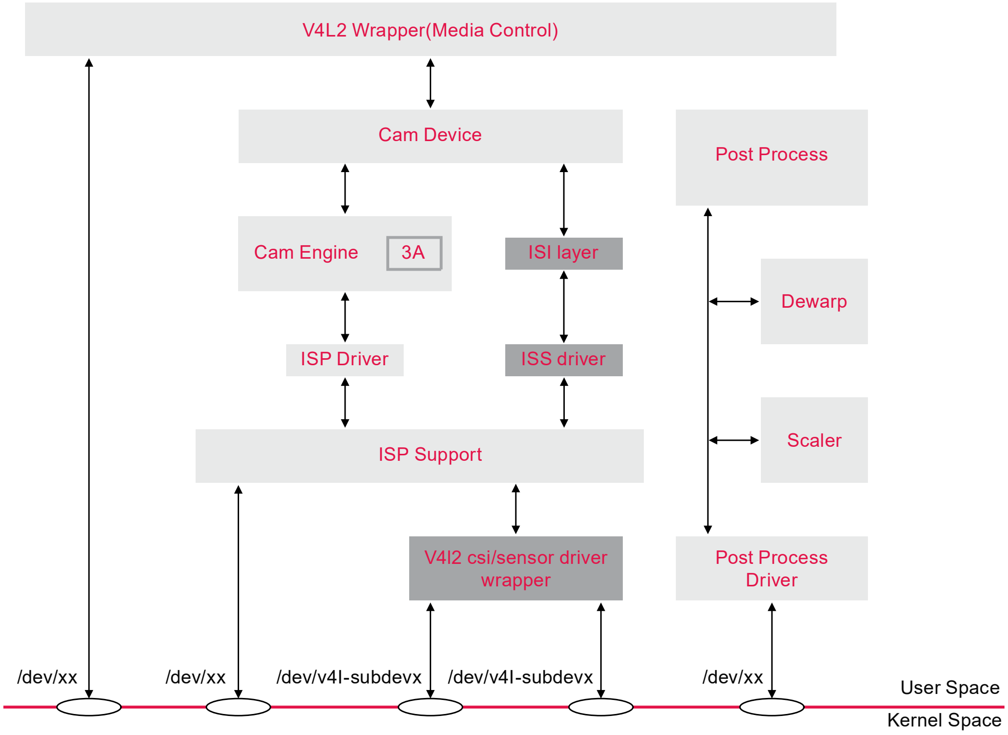

Figure 16. ISP proprietary software stack

3.4 Arbitrary Resolution Control

3.4.1 Introduction to Arbitrary Resolution

All resolutions are limited, where the minimum resolution is 176x144 and the maximum resolution is the sensor output resolution (refer to the sensor specification). The VIDIOC_S_FMT IOCTL which sets the format information must be aligned with width 16 and height 8.

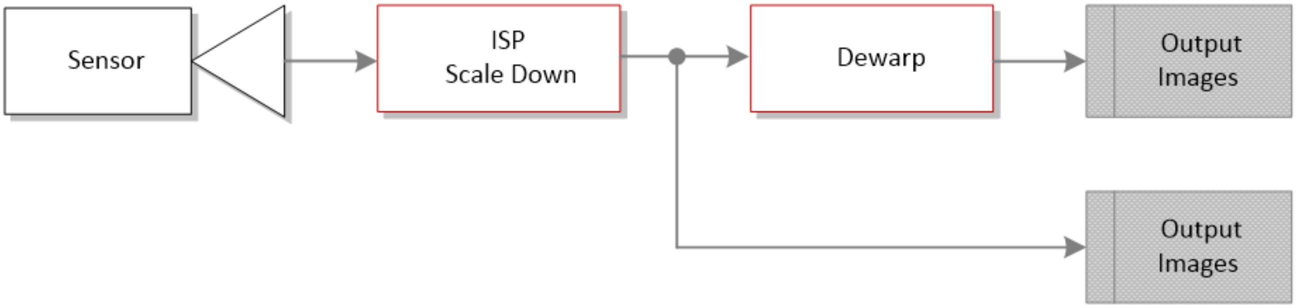

Figure 17. ISP Image Output Flow

The image output flow is shown in the figure above. If the Dewarp output is used, the data after the ISP scale down is used as the input of the Dewarp module. Thus, the Dewarp correction parameters must be calibrated according to the size of the Dewarp input image. If there is no calibration parameter with the corresponding resolution, the system scales the calibration parameter of the current resolution according to the existing calibration parameters. In this case, the converted calibration data is not as accurate as the calibration data. Therefore, it is recommended to calibrate all resolutions used and add the resulting calibration data to the Dewarp configuration file.

3.4.2 Dewarp Calibration

This section describes dewarp calibration for the ISP + Dewarp IP configuration. It does not apply to the ISP-only case.

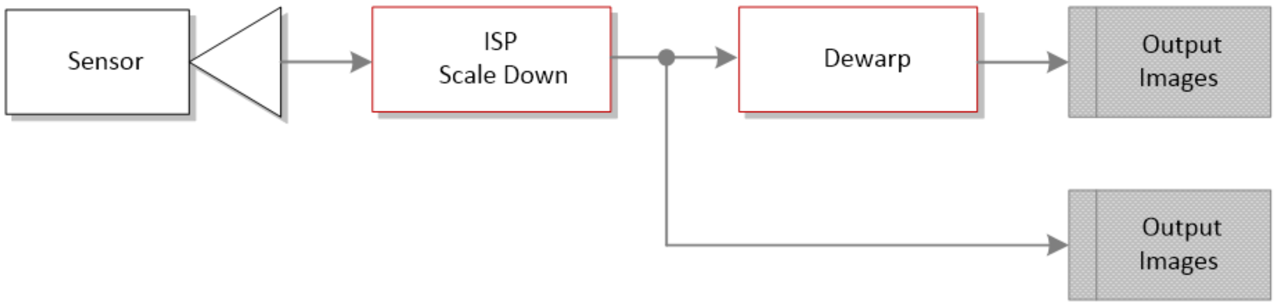

Figure 18. ISP Dewarp Calibration Flow

Use the following steps for Dewarp Calibration:

1. Use a set of default configurations and enable Dewarp bypass.

```
{
    "dewarpConfigArray" :[
        {
            "source_image":{
                "width"  : 1920,
                "height" : 1080
            },

            "?dewarpType": "LENS_CORRECTION, FISHEYE_EXPAND, SPLIT_SCREEN",
            "dewarpType": "FISHEYE_DEWARP",

            "scale": {
                "roix"   : 0,
                "roiy"   : 0,
                "factor" : 1.0
            },

            "split": {
                "horizon_line"      : 540,
                "vertical_line_up"  : 960,
                "vertical_line_down": 960
            },

            "bypass" : true,
            "hflip"  : false,
            "vflip"  : false,
            "camera_matrix"   : [6.5516074404594690e+002,0.0,
                9.6420599053623062e+002,
                 0.0,6.5552406676868952e+002,5.3203601317192908e+002,0.0,0.0,1.0],
            "distortion_coeff": [-2.2095698671518085e-002,3.8543889520066955e-003,-
                5.9060355970132873e-003,1.9007362178503509e-003,0.0,0.0,0.0,0.0],
            "perspective"     : [1.0, 0, 0, 0, 1, 0, 0, 0, 1]

        }
    ]
```

2. Capture YUV image. For example, video test is used to capture 720p YUYV images:

```
./isp_media_server CAMERA0 & ./video_test -w 1280 -h 720 -f YUYV -t 2 -m0 -d0
```

3. Use an online YUV to JPEG image conversion tool to convert the YUV image to a JPEG image.
4. Use the JPEG image and the **Dewarp Calibration Tool** to get the dewarp calibration data. Refer to the document, `Vivante.DW.Calibration.Tool` for more details.
5. Add the dewarp calibration data to the Dewarp configuration file.

```
{
    "dewarpConfigArray" :[
        {
            "source_image":{
                "width"  : 1920,
                "height" : 1080
            },

            "?dewarpType": "LENS_CORRECTION, FISHEYE_EXPAND, SPLIT_SCREEN",
            "dewarpType": "FISHEYE_DEWARP",

            "scale": {
                "roix"   : 0,
                "roiy"   : 0,
                "factor" : 1.0
            },

            "split": {
                "horizon_line"      : 540,
                "vertical_line_up"  : 960,
                "vertical_line_down": 960
            },

            "bypass" : false,
            "hflip"  : false,
            "vflip"  : false,

            "camera_matrix"   : [6.5516074404594690e+002,0.0,
                9.6420599053623062e+002,
                 0.0,6.5552406676868952e+002,5.3203601317192908e+002,0.0,0.0,1.0],
            "distortion_coeff":
[-2.2095698671518085e-002,3.8543889520066955e-003,-
5.9060355970132873e-003,1.9007362178503509e-003,0.0,0.0,0.0,0.0],
            "perspective"     : [1.0, 0, 0, 0, 1, 0, 0, 0, 1]

        }
        {
            "source_image":{
                "width"  : 1280,
                "height" : 720
            },

            "?dewarpType": "LENS_CORRECTION, FISHEYE_EXPAND, SPLIT_SCREEN",
            "dewarpType": "FISHEYE_DEWARP",

            "scale": {
                "roix"   : 0,
                "roiy"   : 0,
                "factor" : 1.0
            },

            "split": {
                "horizon_line"      : 540,
                "vertical_line_up"  : 960,
                "vertical_line_down": 960
            },

            "bypass" : false,
            "hflip"  : false,
            "vflip"  : false,

            "camera_matrix"   : [4.367738293639646e+002,0.0, 6.4280399369082041e+002,
                0.0,4.3701604451245968e+002,3.5469067544795272e+002,0.0,0.0,1.0],
            "distortion_coeff": [-2.2095698671518085e-002,3.8543889520066955e-003,
                -5.9060355970132873e-003,1.9007362178503509e-003,0.0,0.0,0.0,0.0],
            "perspective"     : [1.0, 0, 0, 0, 1, 0, 0, 0, 1]

        }
    ]
}
```

Chapter 4
Revision History

This table provides the revision history.

Table 131. Revision history

Revision number	Date	Substantive changes
L5.4.70_2.3.2	05/2021	Initial release.
LF5.10.35_2.0.0	06/2021	Released for LF5.10.35_2.0.0.
LF5.10.52_2.1.0	10/2021	Major content update for the Linux LF5.10.52_2.1.0 release.
LF5.10.72_2.2.0	12/2021	Updated for the LF5.10.72_2.2.0 release.

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