AX Image Online Tuning Guide

Version: V1.5

Release Date: 2024/08/22

Contents

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Introduction

Applied for

AX620E series (AX630C and AX620Q)

Intended Readers

- Technical Support
- Software Developers

Description of Symbols and Formats

Symbol/Format	Description
`xx`	Stands for command lines that you can execute.
Italic	Stands for variables. For example, the installation directory in "*installation directory*/AX620E_SDK_Vx.x.x/build" is a variable which depends on your actual environment.
☞ Notes:	Provides additional information to emphasize or supplement important points of the main text.
! Notes:	Provides additional information that needs to pay attention to.

Revision History

Version	Release Date	Description
V1.0	01/10/2024	Temporary version released.
V1.1	01/24/2024	Updated parameter description for each module.
V1.2	04/03/2024	Added AWB_MLC/AWB_Green/AE_FaceAE/AE_Piris.
V1.2.2	06/05/2024	Added description for HDR debugMask1.
V1.3	07/13/2024	Updated AWB_MLC & 2DLut.
V1.4	07/17/2024	Updated AWB_Green.
V1.5	08/22/2024	Updated BLC and Raw2dNr modules.

1 Overview

1.1 Introduction

- Tool version: ISPTuning_V1.23.53.1
- Offline Calibration Mode: Refer to the *AX Image Calibration and Debugging Guide*.
- Online Debugging Mode: Online debugging and parameter saving, confirming subjective effects through preview and snapshot.
- Common Auxiliary Tools: Basic image viewing combined with testing functionality to help analyze images.

1.2 Environment Preparation

1.2.1 Hardware Preparation

- Hardware: A standard PC is sufficient.
- Software: Windows 10 operating system.

1.2.2 Hardware Configuration

Hardware Connection

- Connect the PC to the network port of the device directly via Ethernet cable.
- Connect to the network port of the device via local area network.

Serial Port Configuration

1. Confirm the serial port:

a) Right-click the Windows icon.

b) Click “Computer Management”.

c) In the “Computer Management” dialog box that pops up, expand “System Tools” and click “Device Manager”.

d) Click “Ports” on the right side of the page.

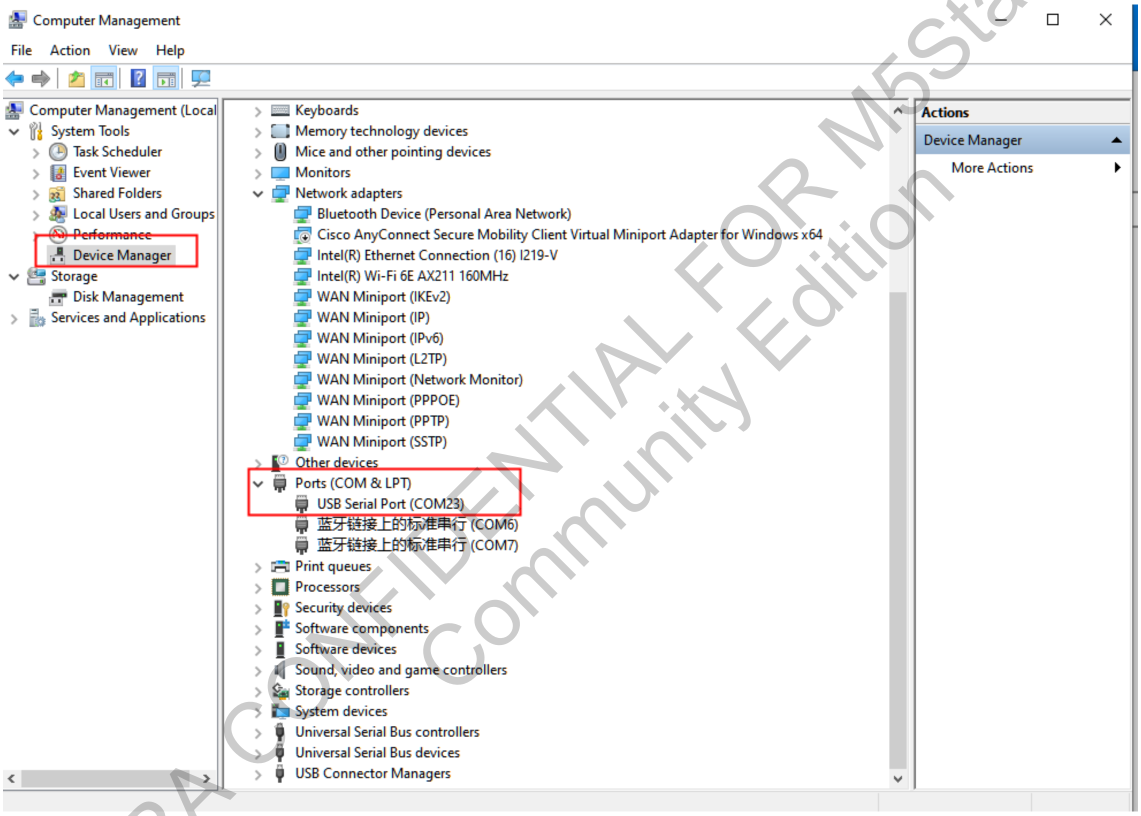


Figure 1-1 Serial Port Configuration

2. Configure the serial port:

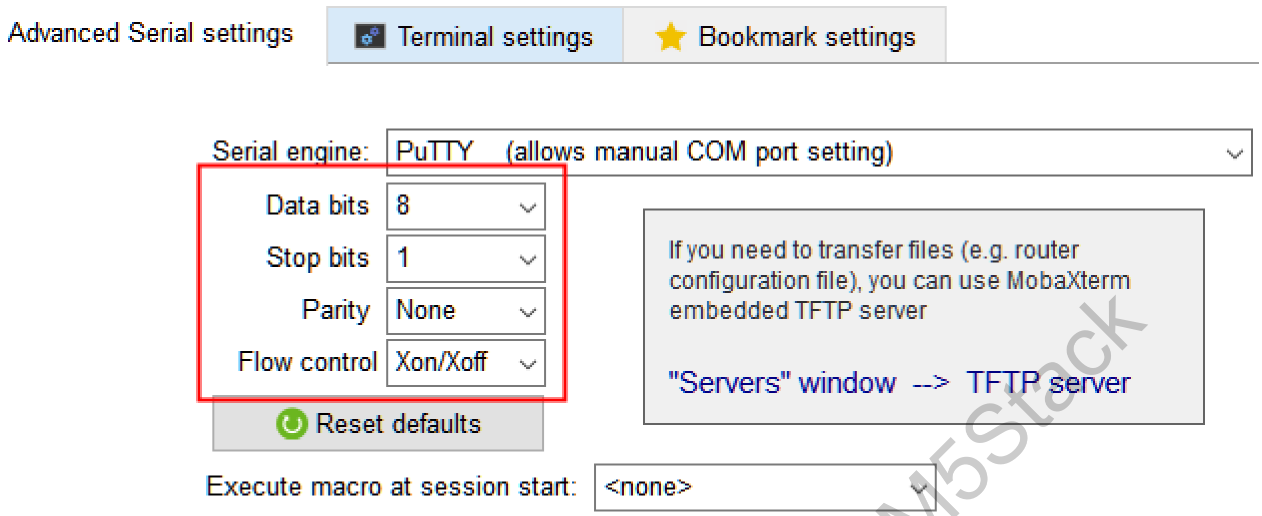


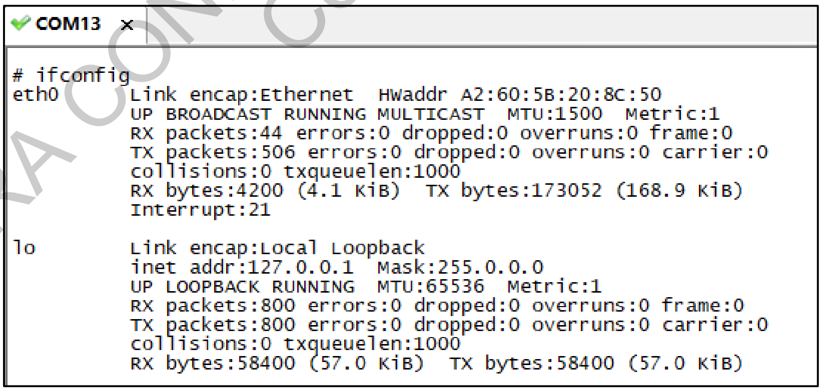
Figure 1-2 Serial Port Configuration

1.2.3 Network Port Configuration

Setting up Network Port

Example commands for operation:

1. To confirm the current network port connection: `ifconfig`.



```
# ifconfig
eth0      Link encap:Ethernet  HWaddr A2:60:5B:20:8C:50
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:44 errors:0 dropped:0 overruns:0 frame:0
          TX packets:506 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:4200 (4.1 KiB)  TX bytes:173052 (168.9 KiB)
          Interrupt:21

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:800 errors:0 dropped:0 overruns:0 frame:0
          TX packets:800 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:58400 (57.0 KiB)  TX bytes:58400 (57.0 KiB)
```

Figure 1-3 Serial Port Example

2. Configure the corresponding network port IP of the motherboard via serial port: `ifconfig`

`eth0 192.168.126.10`.

3. Set the PC configuration to the same network segment as shown below.

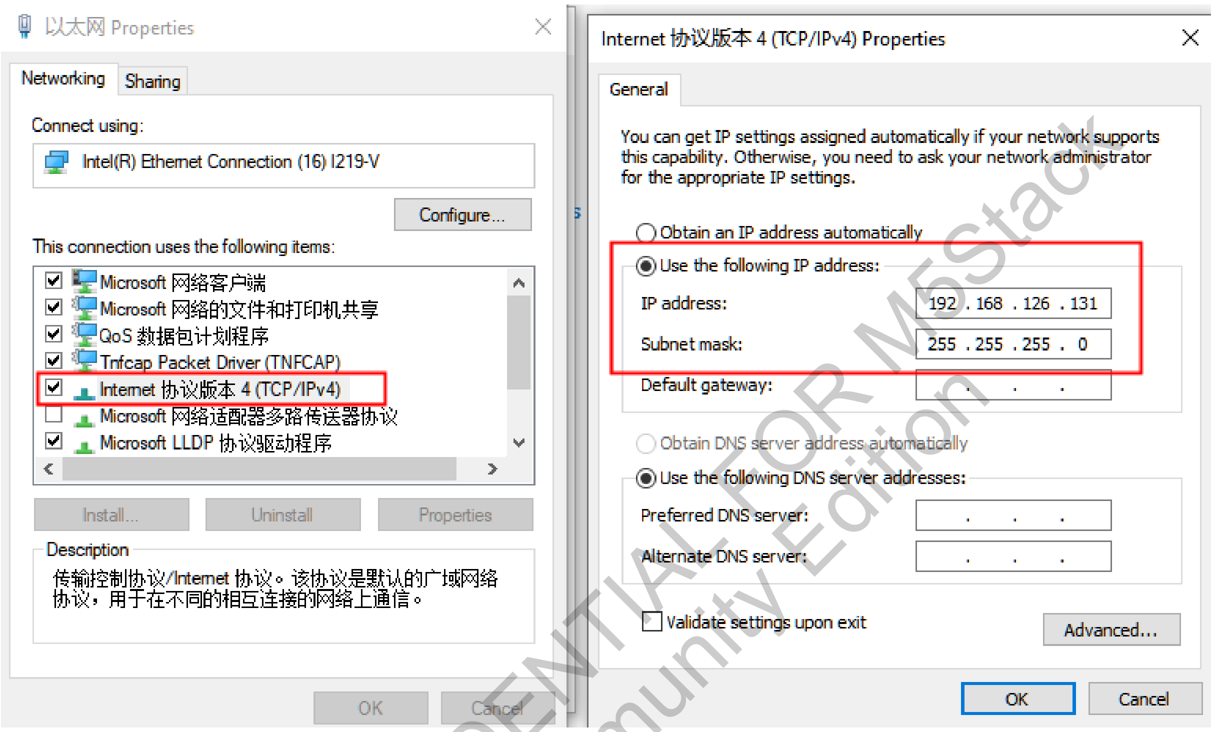


Figure 1-4 Configure IP

Tuning Server Configuration

1. tuning-server.ini: Configures paths for tuning XML, sensor ini, sensor so files, etc.
2. tuning-server.ini path: The configuration file and the tuning-server executable should be placed in the same directory.
3. Usage of tuning-server executable: In the directory containing the tuning-server file, execute directly `./tuning-server -p /opt/etc/"sensor name"_single_"sdr/hdr"_offline_entry.ini`

   For example, for the SC450AI sensor in SDR mode, the command is:

4. `./ tuning-server -p /opt/etc/sc450ai_single_sdr_4lane_entry.ini`

Notes

Assume tuning-server is in the /opt/bin/ directory.

1.2.4 Installing and Running Software

1. Install MCRInstaller.exe.

1) Recommended link for downloading the installation program:

https://www.mathworks.com/products/compiler/matlab-runtime.html.

2) Version: R2013a（8.1）64bit。

2. Run ISPTuning.exe.

2 Pipeline

2.1 Pipeline

Pipeline flowchart of modules in **MC20E**_ISP:

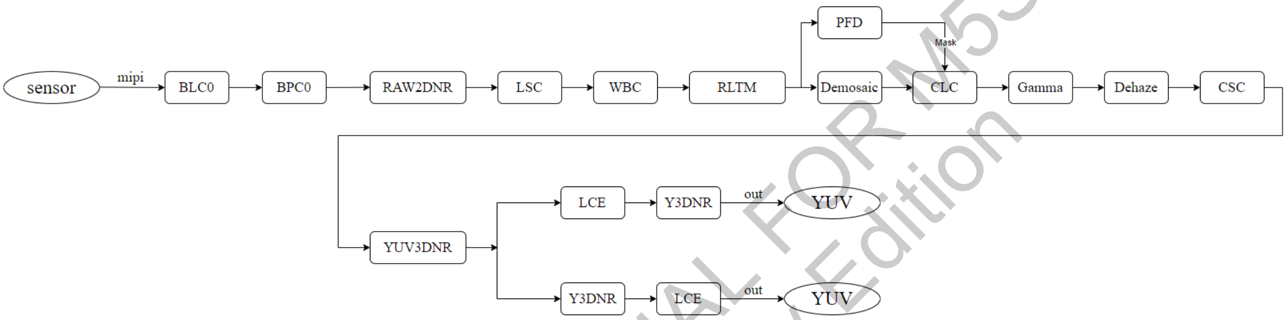


Figure 2-1 MC20E_TISP_SDR_ISP Pipeline

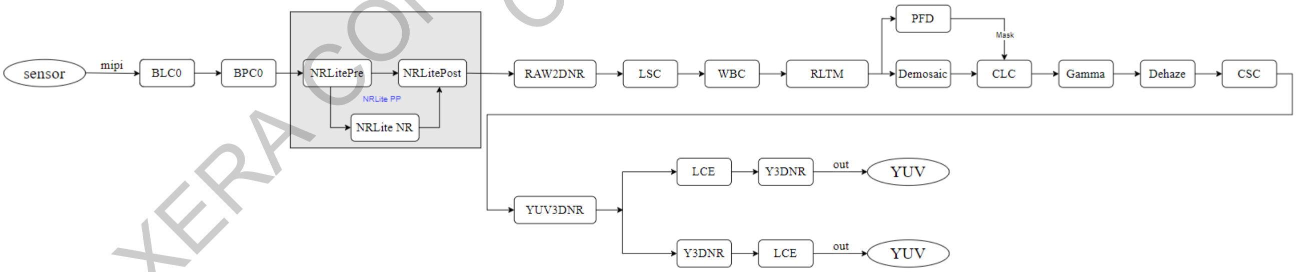


Figure 2-2 MC20E_ AISP_SDR_ISP Pipeline

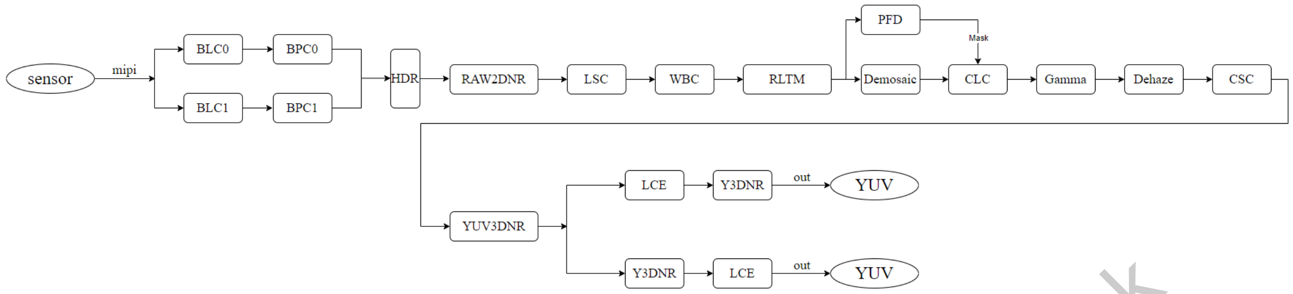


Figure 2-3 MC20E_ TISP_HDR_ISP Pipeline

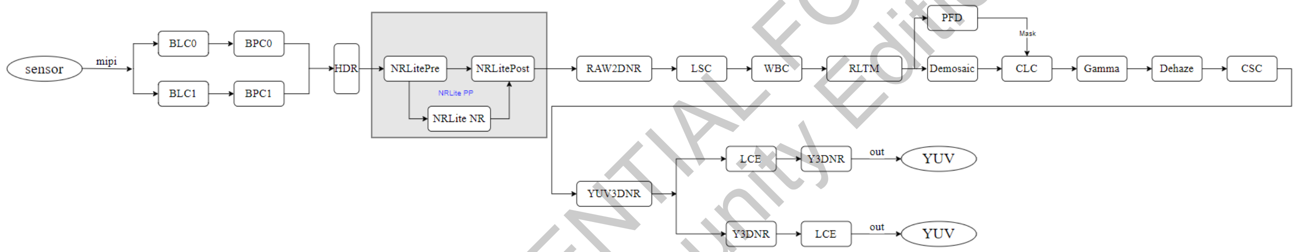


Figure 2-4 MC20E_AISP_HDR_ISP Pipeline

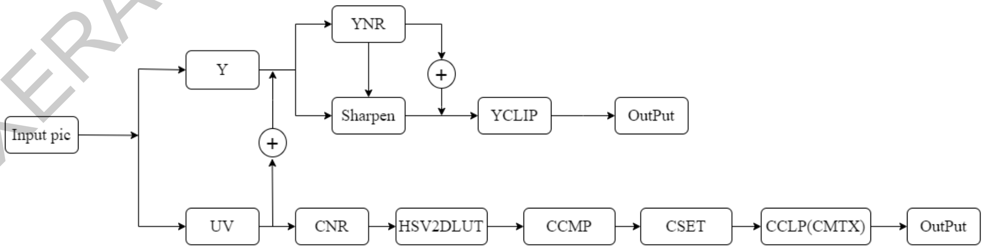


Figure 2-5 MC20E_LCE_ISP Pipeline

3 Tuning Online Modules

3.1 Ae

3.1.1 Introduction

- Supports Auto and Manual modes; switch between them by checking or unchecking the box.
- Check "Enable AE" to view online the Gain, Exposure Time, HCG, and LCG modes of the Sensor.
- Uncheck "Enable AE" to manually adjust the Gain, Exposure Time, HCG, and LCG modes of the Sensor.

3.1.2 Interface

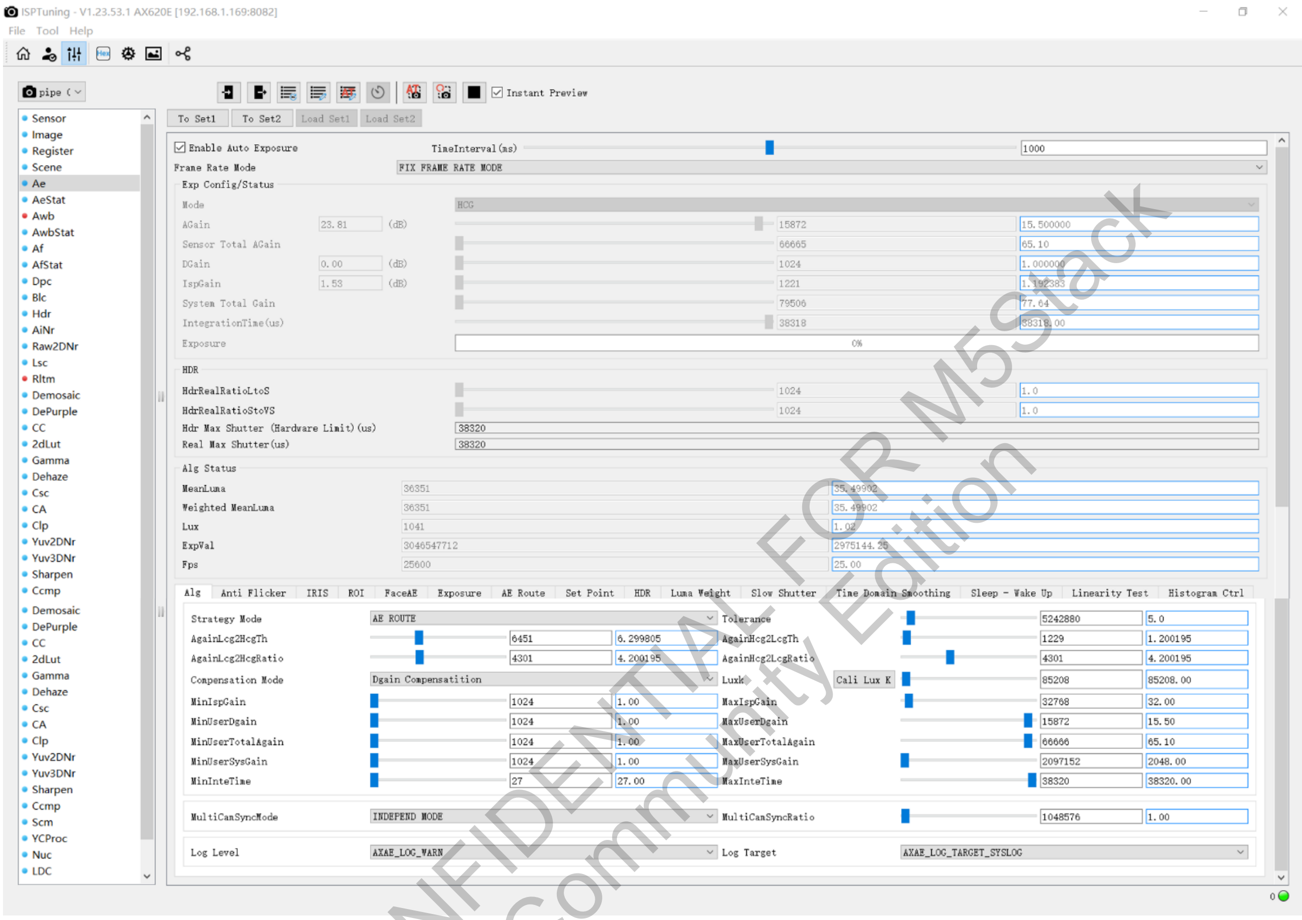


Figure 3-1 AE Interface

3.1.3 Parameter

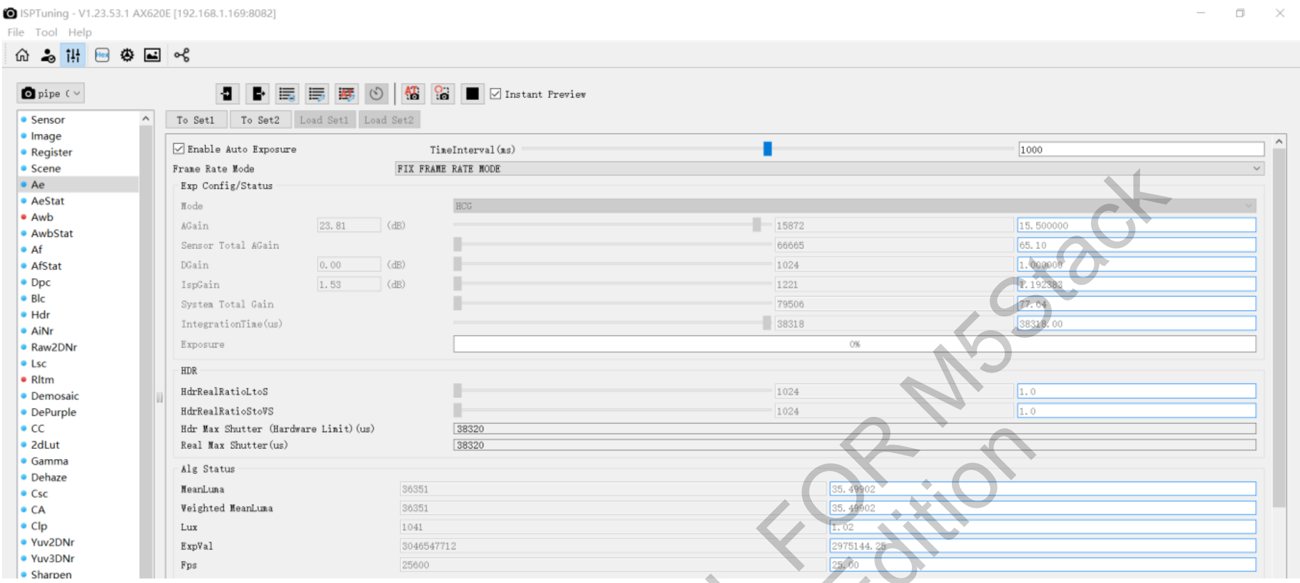


Figure 3-2 AE Interface

- Enable Auto Exposure: Toggle switch for Auto Exposure; on for automatic exposure, off for manual exposure.
- TimeInterval(ms): Refresh time for auto exposure status, in ms. This setting is ineffective when AE is disabled.
- Mode: HCG/LCG mode.
- AGain: Analog Gain. As shown in the diagram, the values in the red box are in dB, those in the blue box are in multiples of gain, and those in the green box are 1024 times the gain (to adapt to the software interface's numerical precision, this is the actual value configured in the software). Other parameters are similar and not repeated here.

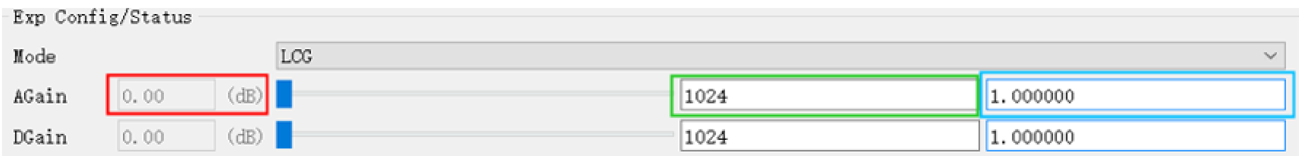


Figure 3-3 Again Parameter Description

- DGain: Digital gain.

- Sensor Total Gain: The total gain provided by the sensor. In LCG mode, Sensor Total Gain = DGain × AGain. In HCG mode, additionally multiply by the gain from HCG mode, thus: Sensor Total Gain = DGain × AGain × HcgRatio.
- ISPGain: Digital gain provided by the ISP chip.
- System Total Gain: In LCG mode, System Total Gain = DGain × AGain × ISPGain. In HCG mode, System Total Gain = DGain × AGain × ISPGain × HcgRatio.
- IntegrationTime(us): Sensor exposure time.
- HDR RealRatioLtoS: The exposure ratio of long to short frames in HDR mode.
- HDR RealRatioStoVS: The exposure ratio of short to very short frames in HDR mode.
- MeanLuma: Average luminance currently measured.
- Lux: Current light level calculated.
- ExpVal: Current exposure rate. ExpVal = System Total Gain × IntergrationTime.
- Fps: Current frame rate.

Description of ALG Parameter

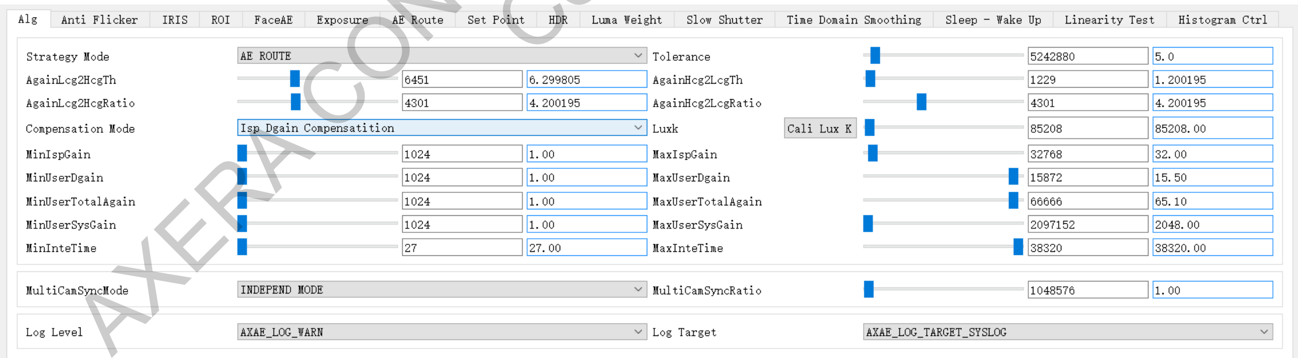


Figure 3-4 Description of AE General Parameter

- Strategy Mode: Exposure Strategy Mode Selection
  - Shutter Priority Mode (When the environment darkens, prioritize increasing exposure time)
  - Gain Priority Mode (When the environment darkens, prioritize increasing gain)

- Exposure Path Mode (Adjust according to exposure strategy when the environment darkens, see the Exposure Path chapter for details)

- Tolerance: SetPoint tolerance value. This is a percentage, indicating that meanluma is allowed to vary between setpoint × (1 + tolerance) and setpoint × (1 - tolerance).
- AgainLcg2HcgTh: AGain must reach this value before switching from LCG to HCG.
- AgainHcg2LcgTh: AGain must decrease to this value before switching from HCG to LCG.
- AgainLcg2HcgRatio: Gain multiplier for HCG. When switching from LCG to HCG, divide by this value.
- AgainHcg2LcgRatio: Gain multiplier for HCG. When switching from HCG to LCG, multiply by this value, recommended to be consistent with AgainLcg2HcgRatio.
- CompensationMode: Compensation method for AGain gear precision.
  - Again Compensatory: Use only AGain without precision compensation.
  - Dgain Compensatory: Use Dgain to compensate for AGain gear precision.
  - Ispgain Compensatory: Use ISPGain to compensate for AGain gear precision.
- Luxk: Used for calibrating Lux. For more details, refer to AX620-Image Calibration and Debugging Guide.
- MinIspGain: Minimum limit value for ISP gain.
- MaxIspGain: Maximum limit value for ISP gain.
- MinUserDgain: Minimum limit value for digital gain.
- MaxUserDgain: Maximum limit value for digital gain.
- MinUserAgain: Minimum limit value for analog gain.
- MaxUserAgain: Maximum limit value for analog gain.
- MinInteTime: Minimum limit value for exposure time.
- MaxInteTime: Maximum limit value for exposure time.

- Multi Cam Sync Mode: Types of multi-camera synchronization mode
  - Independ Mode: Independent mode (recommended for single camera)
  - Master Slave Mode: Dual camera synchronization mode
  - SPLIT HDR Mode: Adjust brightness based on the overlapping area of dual cameras
  - SPLICE Mode: Dual camera production line calibration mode, uses the average brightness of the primary and secondary cameras
- Multi Cam Sync Ratio: Sensitivity of AE in dual-camera setups

Description of Anti-Flicker Parameter

- FlickerPeriod: Frequency for anti-power frequency interference (100HZ/120HZ)
- AntiFlicker Tolerance(us): Tolerance for anti-power frequency interference
- Over Exp Mode: Anti-flicker mode for bright environments
  - LUMA PRIOR: Brightness priority, prioritizes preventing overexposure; activating this may cause flicker in bright environments
  - ANTI PRIOR: Anti-flicker priority, prioritizes flicker prevention; activating this may cause overexposure in bright environments
- Under Exp Mode: Anti-flicker mode for dark environments
  - LUMA PRIOR: Brightness priority, prioritizes preventing overexposure; activating this may cause flicker in dark environments
  - ANTI PRIOR: Anti-flicker priority, prioritizes flicker prevention; activating this may cause underexposure in dark environments

Description of ROI Parameter

Figure 3-5 ROI Module Description

- ➢ Mode:
  - ■ Disable Frame Average Mode
  - ■ Grid Mode Center Weight Mode
  - ■ ROI Mode (Region of Interest Mode)
- ➢ ROI (x, y, w, h): Location and size of Area 1.
  - ■ X and y are the coordinates of the top left corner of the screen, in pixels.
  - ■ W and h are the width and height of the region of interest, in pixels.
- ➢ Weight1: Weighting of the selected Area 1.
- ➢ Weight2: Weighting of areas outside the selected Area 1.

Face AE

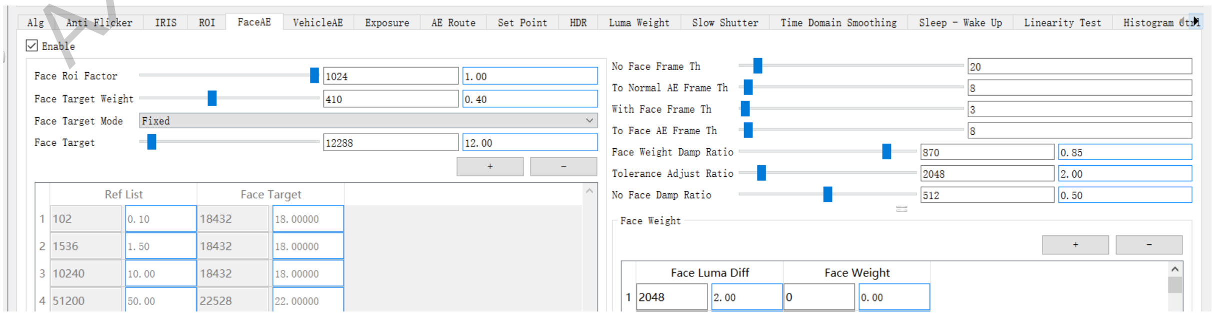


Figure 3-6 Face AE

Parameter Description

- Enable: Switch for FaceAE feature, which follows the human exposure control switch on the web preview interface; tuning preview does not have human detection functionality, and modifying the Enable parameter in the tuning tool interface does not activate this feature. After modifying human exposure prevention enable on the web interface, it is necessary to reconnect the tuning tool.

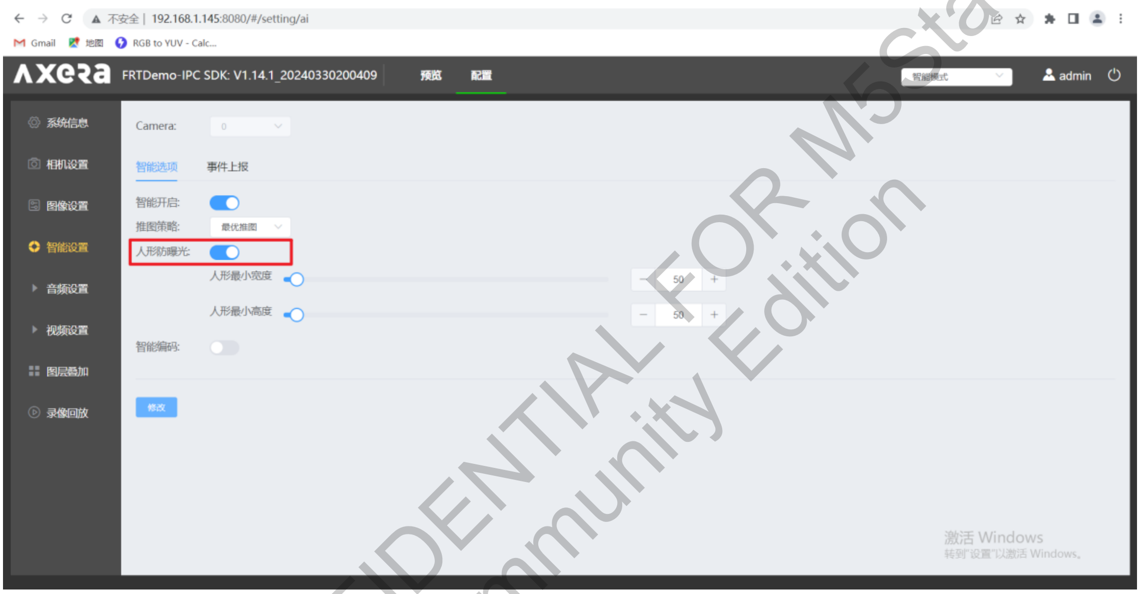


Figure 3-7 Web Interface for Enabling Human Exposure Prevention

- Face Roi Factor: Statistical area for human figure box, with a range of [0, 1]. When set to 1, it calculates the luma (brightness) across the entire detection box. When set to 0.5, it calculates the luma within the lower half of the detection box.

- Face Target Weight: Weight coefficient for the face target, used to adjust the ratio between face target and normal target. The smaller this parameter, the closer the final target is to the setpoint; the larger, the closer it is to the face target.

- Face Target Mode: fixed/lux mode; if fixed is selected, the face target is fixed, if lux mode is selected, the face target is interpolated based on lux.

- Face Target: Used in fixed mode.

- Face Target List: Configured face target values for different lux segments.

- Face Ref List: Used to set the current lux value, in conjunction with the Face Target List to set different face target values.
- No Face Frame Th: Threshold for frames lost without a face; when the number of frames without a face reaches this threshold, the mode begins to switch from faceAE to normalAE. The larger this threshold, the later the switch to normalAE mode begins; the smaller, the earlier the switch starts.
- To Normal Frame Th: Threshold for the number of frames during the switch from face AE to normal AE; the larger this threshold, the longer the switching process; the smaller, the shorter the process.
- With Face Frame Th: Threshold for frames detected with a face; when the number of frames with a face reaches this threshold, the mode begins to switch from normalAE to faceAE. The larger this threshold, the later the switch to faceAE mode begins; the smaller, the earlier the switch starts.
- To Face AE Frame Th: Threshold for the number of frames during the switch from normal AE to face AE; the larger this threshold, the longer the switching process; the smaller, the shorter the process.
- Face Weight Damp Ratio: Temporal smoothing coefficient for face weight. Used to smooth the transition between different levels of face weight; the larger this value, the smoother the transition.
- Tolerance Adjust Ratio: Coefficient for adjusting AE tolerance. When switching to FaceAe and the human detection frame is consistently non-zero, this parameter can be used to increase the AE tolerance.
- No Face Damp Ratio: Temporal smoothing coefficient for face weight after the face is lost from the scene. Used to smooth the transition between different levels of face weight; the larger this value, the smoother the transition.

Face Weight List:

- Configures different levels of face weight based on the difference between face luma and the overall frame’s weighted mean luma.

- The smaller the face luma diff, the closer the brightness of the face area to the overall frame brightness, and the smaller the face weight.
- You can configure different effective face weight values based on different differences between face luma and overall frame weighted mean luma; generally, the larger the difference, the greater the face weight.

Vehicle AE

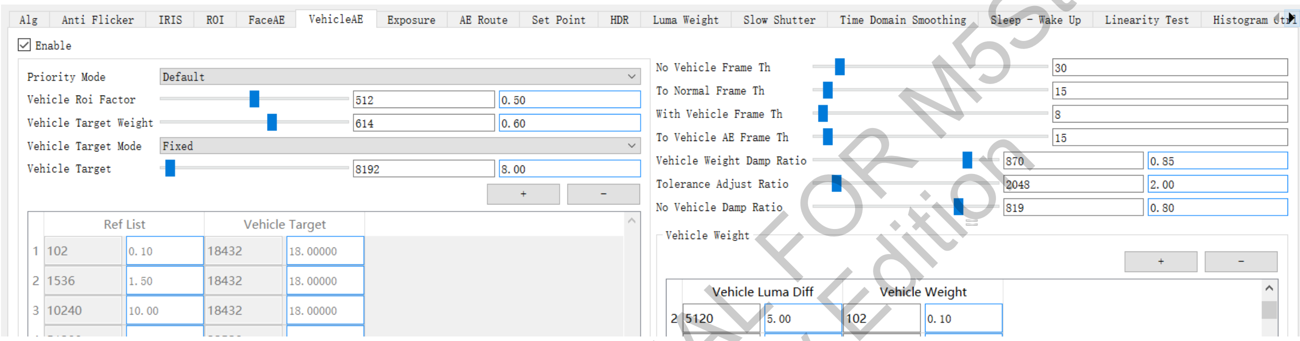


Figure 3-8 Face AE

- Priority Mode: When both FaceAE and VehicleAE are enabled and there are both human and vehicle detection boxes in the scene, you can choose which mode to prioritize for exposure. There are three modes available:
  - default: Both FaceAE and VehicleAE are prioritized equally.
  - vehicle priority: VehicleAE is given priority for exposure.
  - face priority: FaceAE is given priority for exposure.
- Vehicle Roi Factor: Statistical area for vehicle box, with a range of [0, 1]. When set to 1, it calculates the luma (brightness) across the entire detection box. When set to 0.5, it calculates the luma within the lower half of the detection box.
- Face Target Weight: Weight coefficient for the vehicle target, used to adjust the ratio between vehicle target and normal target. The smaller this parameter, the closer the final target is to the setpoint; the larger, the closer it is to the vehicle target.
- Vehicle Target Mode: Fixed/lux mode; if fixed is selected, the vehicle target is fixed, if lux mode is selected, the vehicle target is interpolated based on lux.

- Vehicle Target: Used in fixed mode.
- Vehicle Target List: Configured vehicle target values for different lux segments.
- Vehicle Ref List: Used to set the current lux value, in conjunction with the Vehicle Target List to set different face target values.
- No Vehicle Frame Th: Threshold for frames lost without a vehicle; when the number of frames without a vehicle reaches this threshold, the mode begins to switch from VehicleAE to normalAE. The larger this threshold, the later the switch to normalAE mode begins; the smaller, the earlier the switch starts.
- To Normal Frame Th: Threshold for the number of frames during the switch from Vehicle AE to normal AE; the larger this threshold, the longer the switching process; the smaller, the shorter the process.
- With Vehicle Frame Th: Threshold for frames detected with a vehicle; when the number of frames with a vehicle reaches this threshold, the mode begins to switch from normalAE to VehicleAE. The larger this threshold, the later the switch to VehicleAE mode begins; the smaller, the earlier the switch starts.
- To Vehicle AE Frame Th: Threshold for the number of frames during the switch from normal AE to vehicle AE; the larger this threshold, the longer the switching process; the smaller, the shorter the process.
- Vehicle Weight Damp Ratio: Temporal smoothing coefficient for vehicle weight. Used to smooth the transition between different levels of vehicle weight; the larger this value, the smoother the transition.
- Tolerance Adjust Ratio: An AE tolerance adjustment coefficient used when switching to VehicleAe and the vehicle detection frame is consistently non-zero, allowing for an increase in AE tolerance.
- No Vehicle Damp Ratio: Temporal smoothing coefficient for vehicle weight after the face is lost from the scene. Used to smooth the transition between different levels of vehicle weight.

Vehicle Weight List:

- Configures different levels of vehicle weight based on the difference between vehicle luma and the overall frame's weighted mean luma.
- The smaller the vehicle luma diff, the closer the brightness of the vehicle area to the overall frame brightness, and the smaller the vehicle weight.
- You can configure different effective vehicle weight values based on different differences between vehicle luma and overall frame weighted mean luma; generally, the larger the difference, the greater the vehicle weight.

Exposure Status Statistics

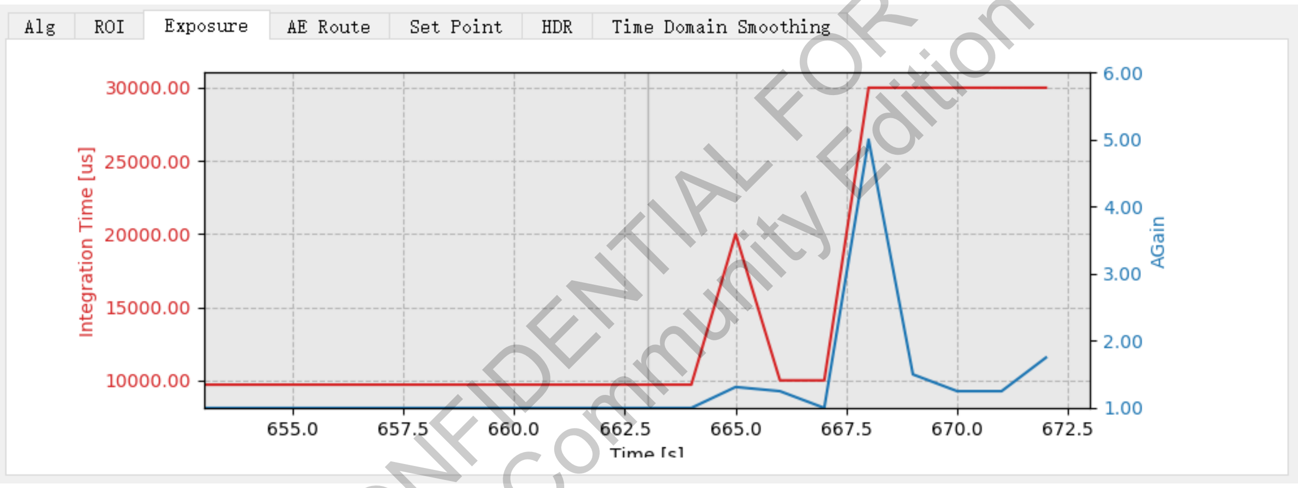


Figure 3-9 Description of Exposure Module

- The above figure shows an exposure line chart: red represents exposure time, and blue represents Total Gain.

AE Route Parameter

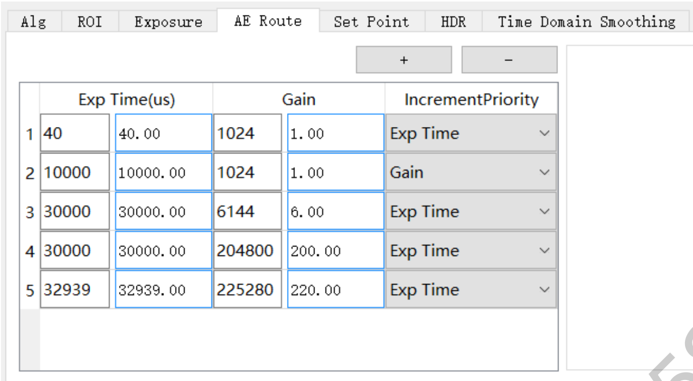


Figure 3-10 Description of AE Route Module

As shown in the above figure, the AE Route page has several AE path points. The current node EV value determines between which two nodes (i-1, i) the current EV value lies, and obtains the exposure time and exposure parameters for the upper and lower nodes. If less than the minimum node, use the minimum node EV; if greater than the maximum node, use the maximum node EV. The "+" and "-" buttons can be used to add or delete nodes. Each node can be individually set for exposure priority or gain priority.

- Exp Time (us): Exposure time for that node
- Gain: Gain for that node (total gain, including AGain, DGain, and ISPGain)
- Increment Priority: Growth mode for that node, where 0 represents prioritizing increase in exposure time, and 1 represents prioritizing increase in gain.

AE Route Settings Description:

- Prerequisite: Effective only when Strategy Mode = AE ROUTE, as shown in the figure below.

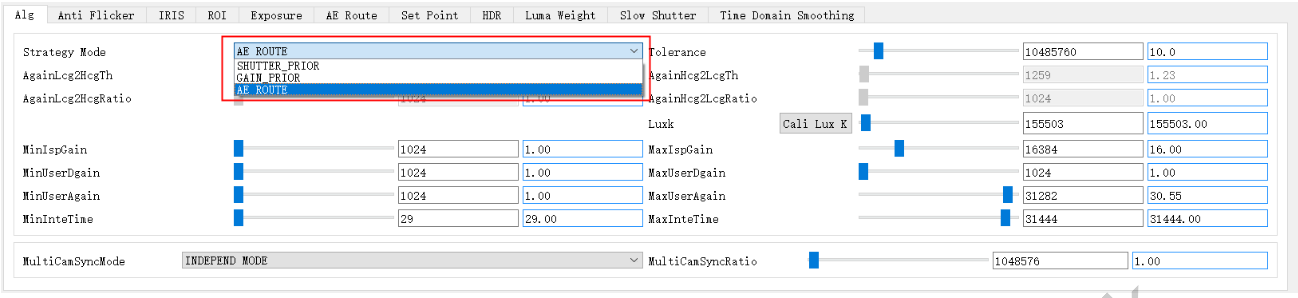


Figure 3-11 AE Route Mode Setting

- The exposure value of a node is the product of exposure time and gain. The exposure value of nodes must monotonically increase, i.e. the exposure value of each subsequent node is greater than that of the previous node. The first node has the minimum exposure value, while the last node has the maximum exposure value.
- Setting nodes with equal exposure values is not supported.
- If the exposure value increases between adjacent nodes, this can be achieved by increasing either one component or both components simultaneously.
- If only a single component increases, the increased component determines the allocation strategy for that segment of the route, and it needs to match the allocation strategy specified in the node (adjusting exposure time alone might lead to the failure of anti-flicker).
- If both components change simultaneously, then the allocation is done according to the strategy defined in the node. To ensure normal operation of the anti-flicker feature, it is recommended to adjust the gain simultaneously with exposure time changes. The allocation strategy will determine whether to prioritize increasing exposure time or gain.
- When the anti-flicker function is enabled, it prioritizes ensuring anti-flicker operation, which may result in the actual effective route differing from the set route.
- In such cases, even if an exposure time priority strategy is set, gain will be adjusted first. The exposure time will only be prioritized for adjustment when the brightness change allows for the exposure time to shift from one anti-flicker stop to another.

- A maximum of 16 nodes are supported, with each node having three components: exposure time, gain, and allocation strategy. Gain includes sensor analog gain, sensor digital gain, and ISP digital gain.

Take os04a10 for example.

- **Scenario 1: Fixed frame rate at 30fps**

As the environment transitions from bright to dark, if you want to set the exposure path as follows: gain remains at 1x, exposure time increases from 20us to 10ms, then increase gain until it reaches 4x, start increasing exposure time again until it reaches 30ms, continue increasing gain up to 1054x, and finally increase exposure time until 32.939ms (maximum hardware exposure time). The exposure can be divided into the following nodes:

1 shutter = 20us gain = 1x

2 shutter = 10ms gain = 1x

3 shutter = 10ms gain = 4x

4 shutter = 30ms gain = 4x

5 shutter = 30ms gain = 1054x

6 shutter = 32.939ms gain = 1054x

Node 2 can be omitted, only nodes 1 and 3 are needed, and in node 1, select Exp Time as the priority. (Situation where both components change simultaneously)

Node 4 can be omitted, only nodes 3 and 5 are needed, and in node 3, select Exp Time as the priority. (Situation where both components change simultaneously)

The AE route you need to set would be:

	Exp Time (us)	Gain	IncrementPriority
1	20	1	Exp time

2	10000	4	Exp time
3	30000	1054	Exp time
4	32939	1054	Exp time

☞ Notes

When Anti-Flicker mode is active, as EV changes from node 2 to node 3, the actual path will prioritize increasing gain until an exposure of 20ms is permissible, then increase the exposure time to 20ms. If the set exposure path prioritizes increasing exposure time first, such as from 10 ms to 15 ms, Anti-Flicker fails. To ensure the Anti-Flicker function, the actual effective path differs from the set path.

➢ **Scenario 2: Frame rate reduction to 25fps**

Assuming the frame reduction requirements are as follows:

1) Without frame reduction, the exposure time reaches 39.888ms (the maximum hardware value).

2) When the gain exceeds 65x, start reducing the frame rate to 15fps, and continue until reaching the maximum exposure time for 15fps. At 15fps, increase the gain to 260x.

3) When the gain exceeds 150x, start reducing the frame rate to 5fps, and continue until reaching the maximum exposure time for 5fps. At 5fps, increase the gain to 1054x.

4) During this period, flicker resistance must be maintained.

Divide the exposure into the following nodes based on the requirements:

1) shutter = 27us, gain = 1x, prioritize increasing exposure time. Node 1→2 needs to reach the maximum exposure time first according to the requirements, then increase gain, thus prioritize increasing exposure time.

2) shutter = 39.888ms, gain = 65x, prioritize increasing exposure time (thus completing Requirement 1). To ensure flicker resistance, the gain needs to increase by more than 2x, derived from the 20ms/10ms ratio, considering the anti-flicker tolerance configuration, it is recommended to configure at least 2.5x gain for a margin.

- When the anti-flicker function is enabled, it prioritizes ensuring anti-flicker operation, which may result in the actual effective route differing from the set route. In such cases, even if an exposure time priority strategy is set, gain will be adjusted first. The exposure time will only be prioritized for adjustment when the brightness change allows for the exposure time to shift from one anti-flicker stop to another. If you follow the set exposure path exactly, you would experience exposure times like 11ms, 13ms, 17ms, etc., which can cause flickering.

- The maximum exposure time for 25fps hardware is 39.888ms, so the shutter is configured to 39.888ms. Configure the anti-flicker tolerance to 112us; if set to 0, the gain would increase to 32x after 30ms, then increase the exposure time to 39.888ms. After setting anti-flicker tolerance to 112us, exposure time will be prioritized up to 39.888ms before increasing gain to 65x.

3) Node 2→3, according to the requirement, reduce the frame rate before increasing gain, therefore choose to prioritize increasing exposure time:

shutter = 66.489ms, gain = 260x, prioritize increasing exposure time (thus completing Requirement 2). To ensure flicker resistance, the gain needs to increase by more than 1.25x, derived from the 50ms/40ms ratio, considering the anti-flicker tolerance configuration, it is recommended to configure at least 1.5x gain for a margin.

- When the anti-flicker function is enabled, it prioritizes ensuring anti-flicker operation, which may result in the actual effective route differing from the set route. In such cases, even if an exposure time priority strategy is set, gain will be adjusted first. The exposure time will only be prioritized for adjustment when the brightness change allows for the exposure time to shift from one anti-flicker stop to another. If you follow the set exposure path exactly, you would experience exposure times like 45ms, 55ms, 57ms, etc., which can cause flickering.
- The driver cannot configure an accurate 15fps; the maximum exposure for 15fps on the 04A is 66.489ms. If set to 66.667ms, it would shift to 14fps, so it must be configured to 66.489ms to ensure the frame reduction to 15fps. To enhance flicker resistance, it is recommended to set the exposure time to an integer multiple of the power frequency (60ms), thus reducing the frame rate to 16 frames per second. Otherwise, as the environmental brightness decreases, if the exposure is maintained at 66.489ms, flickering

may occur.

4. Node 3→4, the requirement is to reduce the frame rate before increasing gain, therefore choose to prioritize increasing exposure time:

- Shutter = 199.835ms, gain = 1054x (thus completing Requirement 3).

  To ensure flicker resistance, the gain needs to increase by more than 1.17x, derived from 70ms/60ms ratio, considering the anti-flicker tolerance configuration, it is recommended to configure at least 1.5x gain for a margin.

- When the anti-flicker function is enabled, it prioritizes ensuring anti-flicker operation, which may result in the actual effective route differing from the set route. In such cases, even if an exposure time priority strategy is set, gain will be adjusted first. The exposure time will only be prioritized for adjustment when the brightness change allows for the exposure time to shift from one anti-flicker stop to another. If you follow the set exposure path exactly, you would experience exposure times like 88ms, 115ms, 197ms, etc., which can cause flickering.

- The driver cannot configure an accurate 5fps; the maximum exposure for 5fps on the 04A is 199.835ms. If set to 200ms, it would shift to 4fps, so it must be configured to 199.835ms to ensure the frame reduction to 5fps.

The AE ROUTE of the node configuration should be set as the following table shows.

	Exp Time (us)	Gain	IncrementPriority
1	27	1	Exp time
2	39888	65	Exp time
3	66489	260	Exp time
4	199835	1054	Exp time

If there are strict requirements for flicker resistance, the following version is more recommended: first reduce the frame rate to 16fps, then to 5fps.

	Exp Time (us)	Gain	IncrementPriority

1	27	1	Exp time
2	39888	65	Exp time
3	60000	260	Exp time
4	199835	1054	Exp time

Description of P-IRIS Function

P-Iris, as a sub-function of the AE algorithm, is composed of a P-Iris lens and specific software control logic. The software controls the movement of the motor within the P-Iris lens to achieve precise control of the aperture.

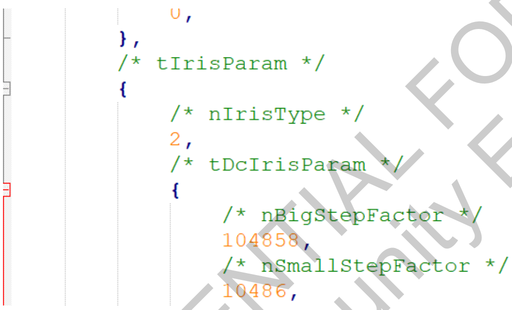


Figure 3-12 P-Iris Mode Activation Settings

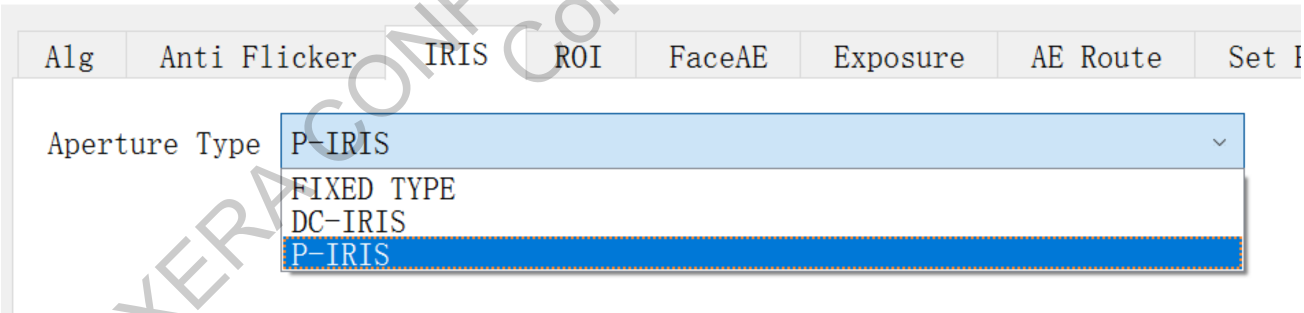


Figure 3-13 Dynamic switching of P-Iris mode is not currently supported.

! Notes:

Currently, it only supports specifying the nIrisType field as 2 in the tuning file, and then starting via the tuning-server. It does not support dynamic switching through the Aperture Type in the IRIS tab within the tuning_tool after starting the tuning-server.

P-Iris uses the AE Route table to configure the method of aperture control, as shown below:

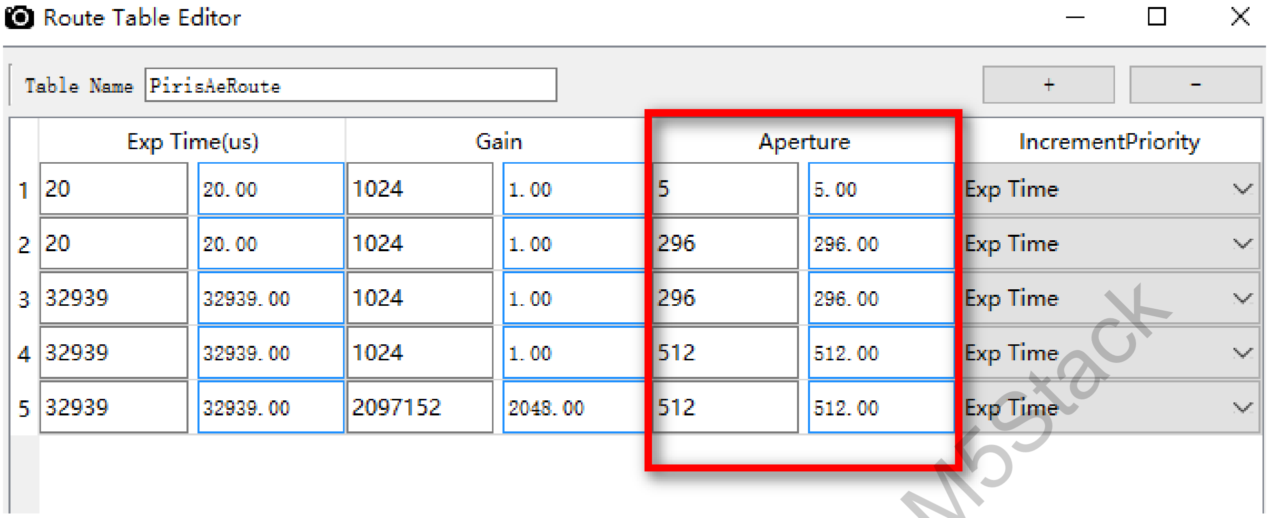


Figure 3-14 P-Iris Aperture Control AE Route

Considerations for the P-Iris AE Route table are as follows:

- The exposure amount at each node, which is the product of exposure time, gain, and aperture (only effective in P-Iris mode), must be monotonically increasing. That is, the exposure amount at each subsequent node must be greater than at the previous node, with the smallest exposure amount at the first node and the largest at the last node. Nodes with equal exposure amounts are not supported.

- In P aperture mode, adjacent nodes only support an increase in one component (not more than two components changing simultaneously).

- Under P-IRIS status, the actual size of the aperture is displayed in the Exp Config/Status.

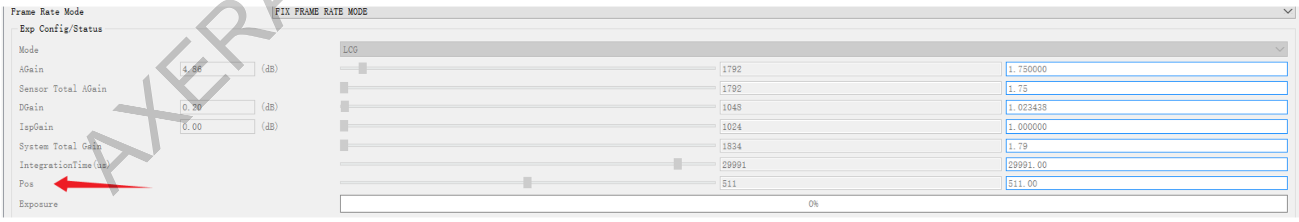


Figure 3-15 Current P-Iris Aperture Value

Description of Target Brightness (Set Point) Parameter

- SetPointMode:

  - GainLut: Uses gain (total gain) as the reference value.

■ LuxLut: Uses lux as the reference value.

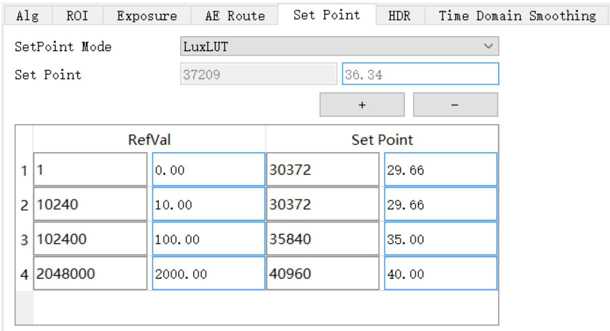


Figure 3-16 Description of Set Point Module

➢ As shown in the figure above, you can choose an automatic strategy for the target brightness (SetPoint) under different reference values (RefValue), with interpolation processing for intermediate states.

■ Fixed: Disables the automatic strategy and uses a fixed SetPoint.

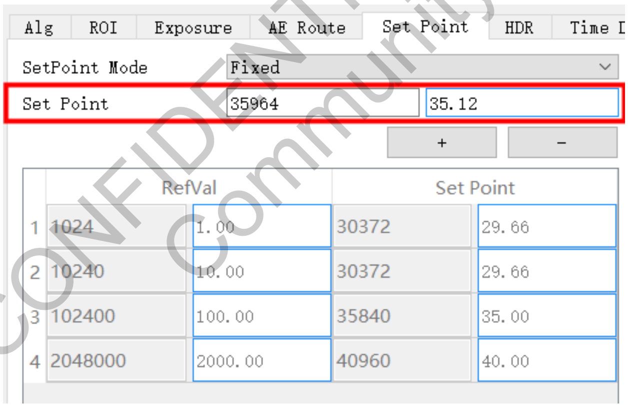


Figure 3-17 Fixed

Description of HDR Parameter

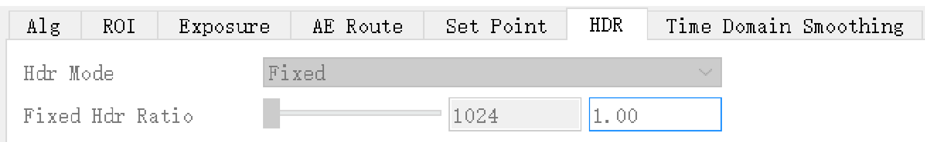


Figure 3-18 Module Description

In the case of an HDR sensor, you can configure the HDR ratio, which is the exposure time ratio between long and short frames.

- HDR Mode: Fixed for fixed ratio mode, and dynamic for dynamic ratio mode
- Fixed HDR Ratio: Exposure time ratio between long and short frames in fixed ratio mode.

Parameters in Dynamic Ratio Mode

- Refval: Lux node, supports up to 10 groups of nodes;
- Min ratio: The minimum HDR ratio achievable under the current Lux node;
- Max ratio: The maximum HDR ratio achievable under the current Lux node;
- Short Frame Saturated Luma: Brightness threshold for short frames under the current Lux node. A lower value makes the short frame darker, better suppressing highlights; conversely, a higher value makes the short frame brighter, worsening highlight suppression. It is advised to adjust this value according to brightness changes: in bright scenes, the average brightness of short frames is high, so the threshold should be lower to prevent overexposure; in dark scenes, the average brightness of short frames is low, so the threshold should be higher to prevent the frames from being too dark;

☞ It is recommended to prioritize adjusting the Short Frame Saturated Luma parameter under dynamic ratio conditions.

HDR Dynamic Strategy Params:

- Suggest Min Ratio: Displays the real-time minimum exposure ratio;
- Suggest Max Ratio: Displays the real-time maximum exposure ratio;
- Short Frame Saturated Luma: Displays the real-time brightness threshold for short frames;
- Short Frame Not-saturated Area Percent: The percentage of pixels in the short frame that are not saturated in brightness. UI interface parameter range: [0, 100], 99.6 by default, recommended not to modify;
- Tolerance: The upper limit of the difference between the actual brightness of the short frame and the user-set Short Frame Saturated Luma. UI interface parameter range: [0, 100], 8 by default;
- Converge Count Frame Num: Convergence frame count, if continuously N frames are within the

tolerance range, then it enters a converged state. UI interface parameter range: [0, 10]. Default parameter is 3 frames;

- DampRatio: Temporal smoothing coefficient, the higher the value, the smoother the effect. UI interface parameter range: [0, 1], 0.9 by default.

Description of Time Domain Smooth

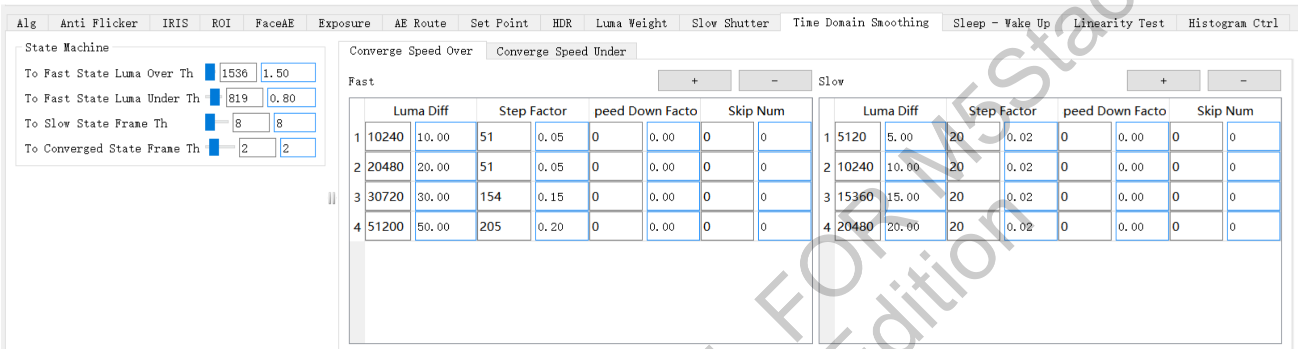


Figure 3-19 Description of Time Domain Smooth

- To Fast State Luma Over Th: Threshold to enter the fast state when the scene is overexposed. When scene brightness is no less than setpoint + (To Fast State Luma Over Th × setpoint), it will enter the Fast state.

Example:

If the current setpoint is 30 and To Fast State Luma Over Th is set to 2, then when the scene brightness is 90 or higher, it will enter the Fast state.

Debugging Effect:

The smaller this value, the easier it is to enter the fast state; however, too small a value can lead to overshooting issues due to too rapid adjustments. The larger this value, the harder it is to enter the fast state; too large a value can lead to overly slow convergence.

- To Slow State Luma Under Th: Threshold to enter the slow state when the scene is underexposed. When scene brightness is no larger than setpoint - (To Slow State Luma Under Th × setpoint), it will enter the Slow state.

Example:

If the current setpoint is 30 and To Slow State Luma Under Th is set to 0.15, then when the scene brightness is 25.5 or lower, it will enter the Slow state.

Debugging Effect:

The smaller this value, the easier it is to shift from a Converged state to a slow state; too small a value can cause flickering when fast-moving objects pass through the scene. The larger this value, the harder it is to shift from a Converged state to a slow state; too large a value can result in underexposure. Note: The tolerance must be greater than or equal to To Slow State Luma Over Th. If this condition is not met, prolonged exposure to brightness fluctuations can occur. For example, if tolerance is 10% and to slowth is 15%, adjustments will not be triggered until the variation exceeds 15%, then quickly adjust to 10%, causing a visible brightness change due to the 5% difference.

➢ To Slow State Frame Th: Frame threshold for entering the slow state; only when continuous N frames (N = To Slow State Frame Th) satisfy the requirements for a slow state will it enter the slow mode.

Debugging Effect:

The smaller this value, the easier it is to shift from a Converged state to a slow state; too small a value can cause flickering when fast-moving objects pass through the scene. The larger this value, the harder it is to shift from a Converged state to a slow state; too large a value can result in underexposure/overexposure.

➢ To Converged State Frame Th: Frame threshold for entering the Converged state; only when continuous N frames (N = To Converged State Frame Th) satisfy the requirements for a Converged state will it enter the Converged mode.

Debugging Effect:

The smaller this value, the easier it is to enter the Converged state; however, too small a value can cause slight overexposure/underexposure. The larger this value, the harder it is to enter the Converged state; too large a value can lead to stable AE, prone to flickering.

Fuzzy PID Parameters

Fuzzy PID consists of four groups of parameters: FastOver, FastUnder, SlowOver, SlowUnder.

Each group contains the following parameters: lumaDiffList, StepFactorList, SpeedDownFactorList, and SkipList. Below is the description of these four groups of parameters.

- lumaDiffList:

lumaDiff = abs(setpoint - curMeanLuma) represents the difference between the current scene brightness and the target brightness. LumaDiffList is a list of differential gear positions, which should show a monotonically increasing trend. Up to 16 positions can be configured, with each position corresponding to a set of parameters. Based on the lumaDiff, determine which node (as shown below) the current setting corresponds to, and use the parameters of that node.

☞ Debugging suggestion: It is advised that the parameters for Under have denser positions at lower lumaDiffs compared to Over, to achieve better convergence.

- StepFactorList:

StepFactor is the AE step adjustment parameter, adjusting steps as a percentage of abs(lumaDiff). The AE adjustment step between two consecutive frames equals abs(lumaDiff) × stepFactor. StepFactorList is a list of AE step adjustment parameters.

Detailed parameter effects:

If the current difference between scene brightness and target brightness is 40:

If stepFactor is set to 0.2, the next frame will adjust the scene brightness to curMeanLuma + lumaDiff × 0.2, i.e., nextFrameMeanLuma = curMeanLuma + 8;

If stepFactor is set to 0.5, the next frame will adjust the scene brightness to curMeanLuma + lumaDiff × 0.5, i.e., nextFrameMeanLuma = curMeanLuma + 20;

If stepFactor is set to 1, the next frame will adjust to curMeanLuma + lumaDiff × 1, i.e., nextFrameMeanLuma = curMeanLuma + 40;

The larger this value, the faster the AE convergence speed. However, if this value is too large, it can easily lead to overshooting. Conversely, the smaller this value, the slower the convergence speed.

☞ Tuning advice: It is recommended to increase StepFactor as lumaDiff increases, to speed up convergence in scenes with large brightness differences. It is advisable to configure Fast to converge faster than Slow and set Under to converge slower than Over to match subjective perceptions better.

- SpeedDownFactorList:

SpeedDownFactor is the AE slowdown parameter, reducing steps as a percentage of lumaSpeed, where lumaSpeed = preFrameMeanLuma - curMeanLuma. The slowdown step between two consecutive frames is lumaSpeed × stepFactor. SpeedDownFactorList is a list of AE slowdown parameters.

Detailed parameter effects:

If the scene is underexposed and the brightness continues to increase, the AE adjustment direction is correct, but the speed is too fast, leading to overshooting. Speed Down Factor can prevent overshooting.

If the scene is overexposed and the brightness continues to decrease, the AE adjustment direction is correct, but the speed is too fast, leading to overshooting. Speed Down Factor can prevent overshooting.

If the current state is underexposure and the scene brightness continues to decrease, there are generally two scenarios:

Early Stages of Environmental Change: This occurs in the first few frames when the environment begins to change, and the AE has not yet had time to respond. The Speed Down Factor can be used to quickly adjust as soon as the environmental change starts.

Overshoot: If overshooting has occurred, the Speed Down Factor can help alleviate the overshooting phenomenon.

If the current state is overexposure and the scene brightness continues to increase, there are generally two scenarios:

Early Stages of Environmental Change: This occurs in the first few frames when the environment begins to change, and the AE has not yet had time to respond. The Speed Down Factor can be used to quickly adjust as soon as the environmental change starts.

Overshoot: If overshooting has occurred, the Speed Down Factor can help alleviate the overshooting phenomenon.

When stepFactor is 0:

If SpeedDownFactor is set to 0.2, the next frame will adjust the scene brightness to curMeanLuma + lumaSpeed × 0.2, i.e., nextFrameMeanLuma = curMeanLuma - 8;

If SpeedDownFactor is set to 0.5, the next frame will adjust the scene brightness to curMeanLuma + lumaSpeed × 0.5, i.e., nextFrameMeanLuma = curMeanLuma - 20;

If SpeedDownFactor is set to 1, the next frame will adjust to curMeanLuma + lumaSpeed × 1, i.e., nextFrameMeanLuma = curMeanLuma - 40.

Debugging Effect:

The larger this value, the more obvious the slowing effect. Inappropriate slow-down parameters can lead to incorrect AE adjustment directions.

- Tuning advice: When luma diff is small, and step factor is low, AE adjusts slowly, and there is no need to reduce speed; in fact, reducing speed might cause AE to adjust in the wrong direction, so it's suggested to configure the speed down factor to 0.
- When luma diff is large, typically at the start of sudden environmental changes where brightness quickly deviates from the set point, or after a few frames of a white screen where continuous large steps can lead to overshooting, it may be necessary to slightly increase the speed down factor to adjust AE quickly or prevent overshooting.

- Skip Num:

Skip is the AE frame skipping parameter. A value of 1 means that exposure parameters are adjusted every 2 frames, and so on.

Debugging Effect:

The larger this value, the less smooth the AE convergence, resulting in a more noticeable stepped appearance.

- Tuning advice: At Skip=1, if you closely observe the convergence process, you might notice slight step-like changes in brightness, so it is recommended to keep skip at 0. Only consider using skip to temporarily circumvent issues such as delayed AE statistics or late effectiveness of sensor again shutter.

3.2 AeStat

3.2.1 Introduction

The AeStat module primarily configures the intervals for AE statistical information. Under normal circumstances, it is advisable to use the default configuration, and adjustments are not recommended.

3.2.2 Interface

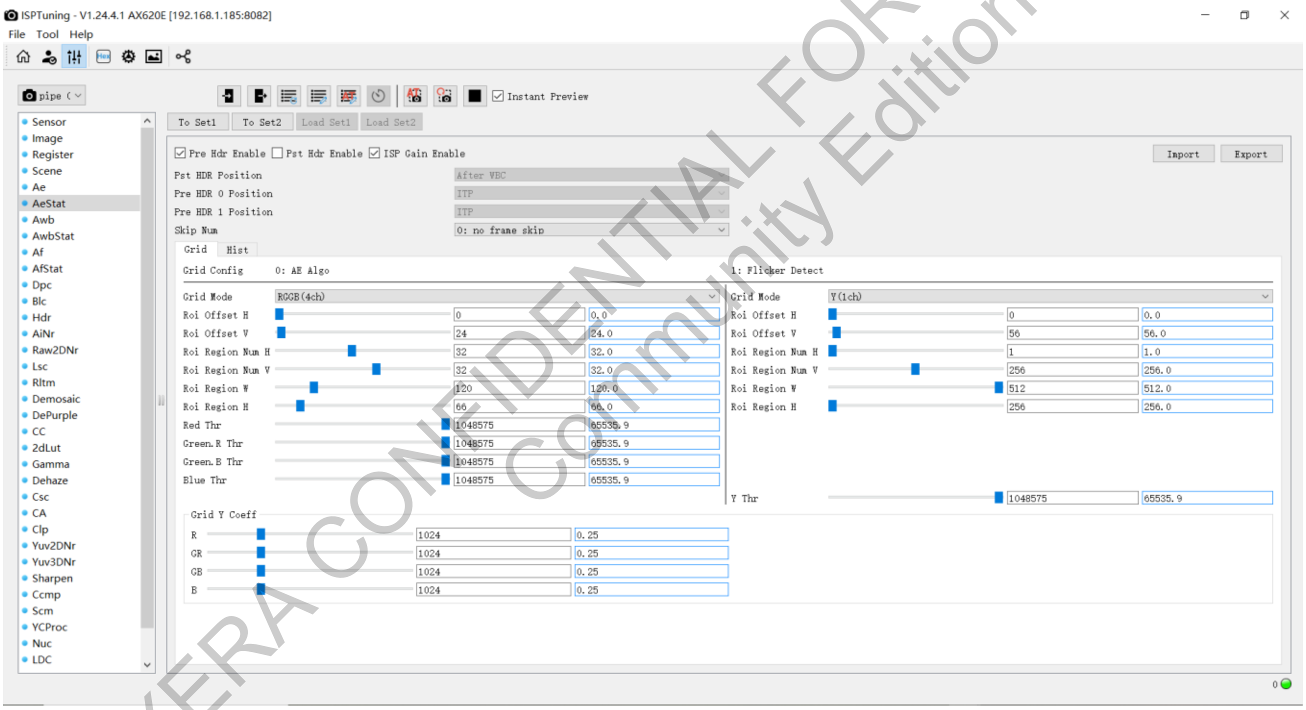


Figure 3-20 AeStat Interface 1

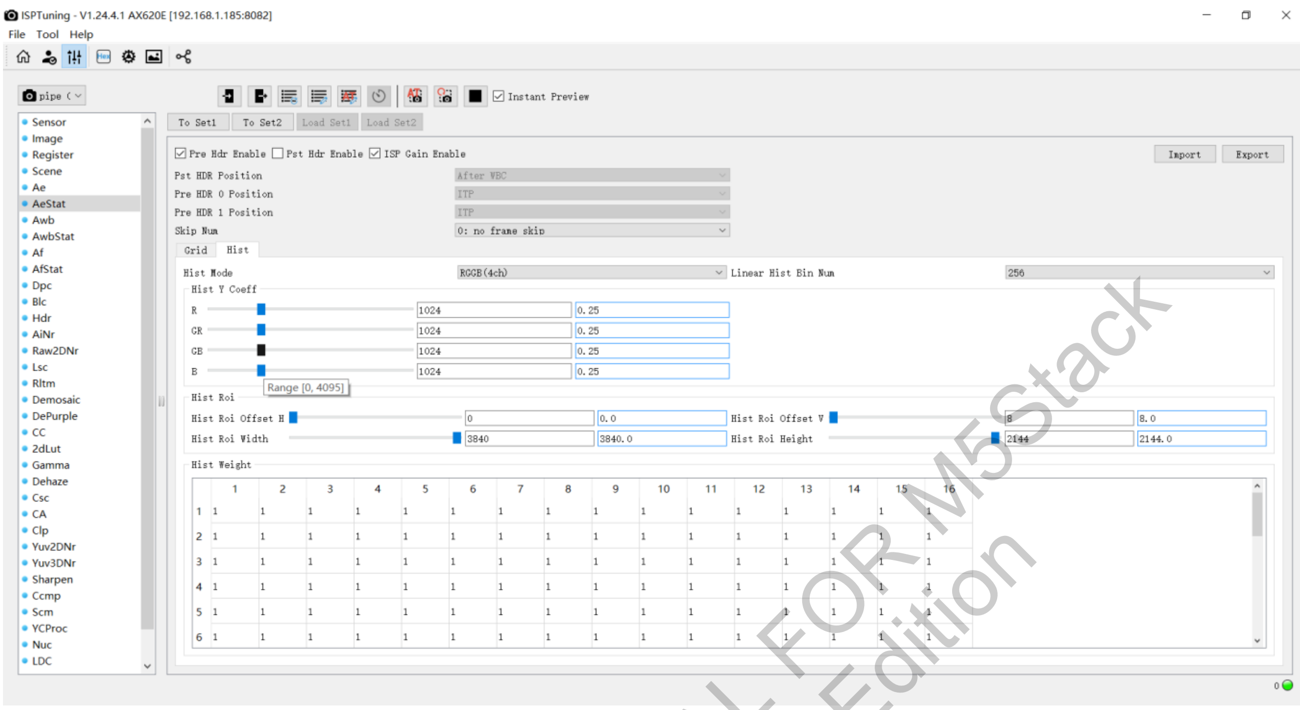


Figure 3-21 AeStat Interface 2

3.2.3 Parameter

AeStat		
Parameter	Description	Range
Pre Hdr Enable	Switch for statistics before the HDR module	0, 1
Pst Hdr Enable	Switch for statistics after the HDR module	0, 1
ISP Gain Enable	Whether to multiply statistics by ISP gain	0, 1
Pst HDR Position	Position of statistics after the HDR module	After WBC
Pre HDR 0 Position	Position of statistics for long frames before the HDR module	ITP
Pre HDR 1 Position	Position of statistics for long frames before the HDR module	ITP
Skip Num	0:no frame skip	0, 1, 2
	1: 1/2 frame skip	
	2: 1/2 frame skip	
Grid		
Grid Config 0: AE Algo		
Grid Mode	Y (1ch)	\
	RGGB(4ch)	\

Roi Offset H	Horizontal offset of the statistical region	0~3839
Roi Offset V	Vertical offset of the statistical region	0~2159
Roi Region Num H	Number of horizontal grids in the statistical region	1~72
Roi Region Num V	Number of vertical grids in the statistical region	1~54
Roi Region W	Width of each statistical grid	16~512
Roi Region H	Height of each statistical grid	2~512
Red Thr	Statistical threshold of the R channel	0~65536
Green.R Thr	Statistical threshold of the GR channel	0~65536
Green.B Thr	Statistical threshold of the GB channel	0~65536
Blue Thr	Statistical threshold of the B channel	0~65536
Flicker Detect		
Grid Mode	Y (1ch)	\
	RGGB(4ch)	\
Roi Offset H	Horizontal offset of the statistical region	0~3839
Roi Offset V	Vertical offset of the statistical region	0~2159
Roi Region Num H	Number of horizontal grids in the statistical region	1~8
Roi Region Num V	Number of vertical grids in the statistical region	1~512
Roi Region W	Width of each statistical grid	16~512
Roi Region H	Height of each statistical grid	256~1024
Y Thr	Statistical threshold of the Y channel	0~65536
Grid Y Coeff		
R	Statistical coefficient of the R channel	0~1
GR	Statistical coefficient of the GR channel	0~1
GB	Statistical coefficient of the GB channel	0~1
B	Statistical coefficient of the B channel	0~1
Hist		
Hist Mode	Y (1ch)	
	YRGB(4ch)	
	RGGB(4ch)	
Linear Hist Bin Num	Number of bins in the linear histogram	256/512/1024
Hist Y Coeff		
R	Statistical coefficient of the R channel histogram	0~1
GR	Statistical coefficient of the GR channel histogram	0~1
GB	Statistical coefficient of the GB channel histogram	0~1
B	Statistical coefficient of the B channel histogram	0~1
Hist Roi		
Hist Roi Offset H	Horizontal offset of the statistical region in the histogram	0~3839
Hist Roi Offset V	Vertical offset of the statistical region in the histogram	0~2159

Hist Roi Width	Width of the histogram statistical region	0~3840
Hist Roi Height	Height of the histogram statistical region	0~2160
Hist Weight Lut	Statistical weight of each block in the histogram	0~255

☞ Notes

The AeStat module primarily configures the intervals for AE statistical information. Under normal circumstances, it is advisable to use the default configuration, and adjustments are not recommended.

3.3 Awb

3.3.1 Introduction

- Supports Auto and Manual modes; switch between them by checking or unchecking the box.
- When "Enable Auto White Balance" is checked, it allows real-time viewing of the values for R-Gain, G-Gain, and B-Gain.
- If "Enable AWB" is unchecked (Manual mode), you can manually adjust the gain values for the R, Gr, B, and Gb channels.
- "Auto Refresh Interval," when selected, displays the AWB log in real-time on the Statistics page; the log refresh time can be set.

3.3.2 Interface

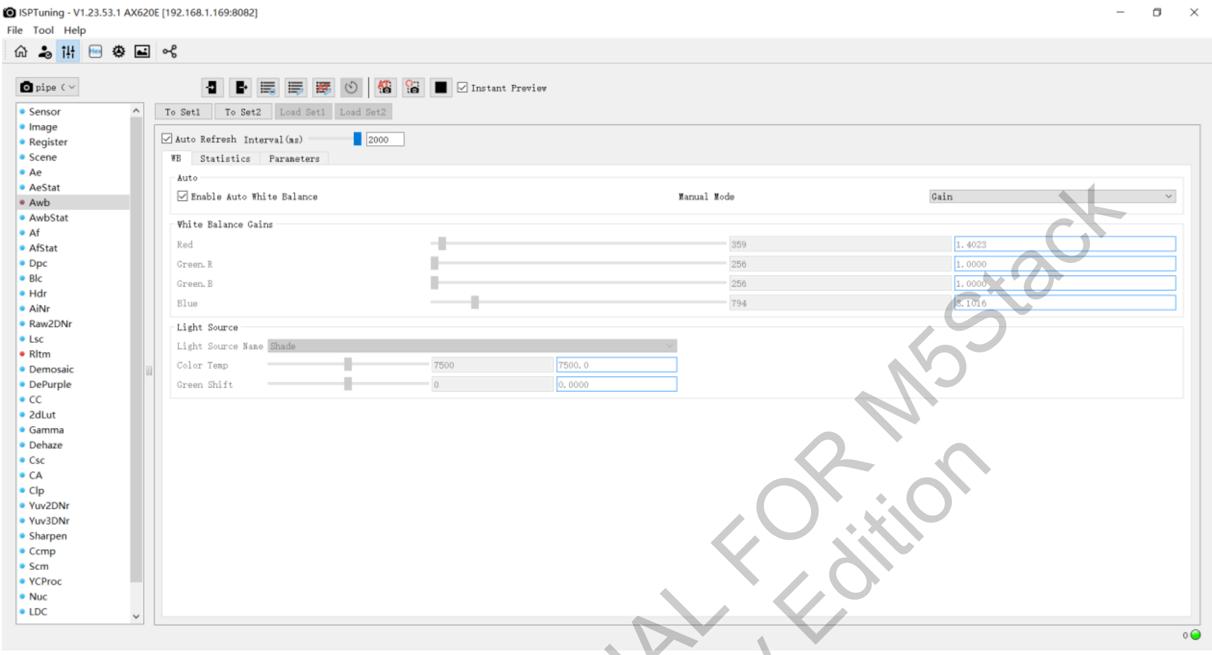


Figure 3-22 AWB Interface

3.3.3 Parameter

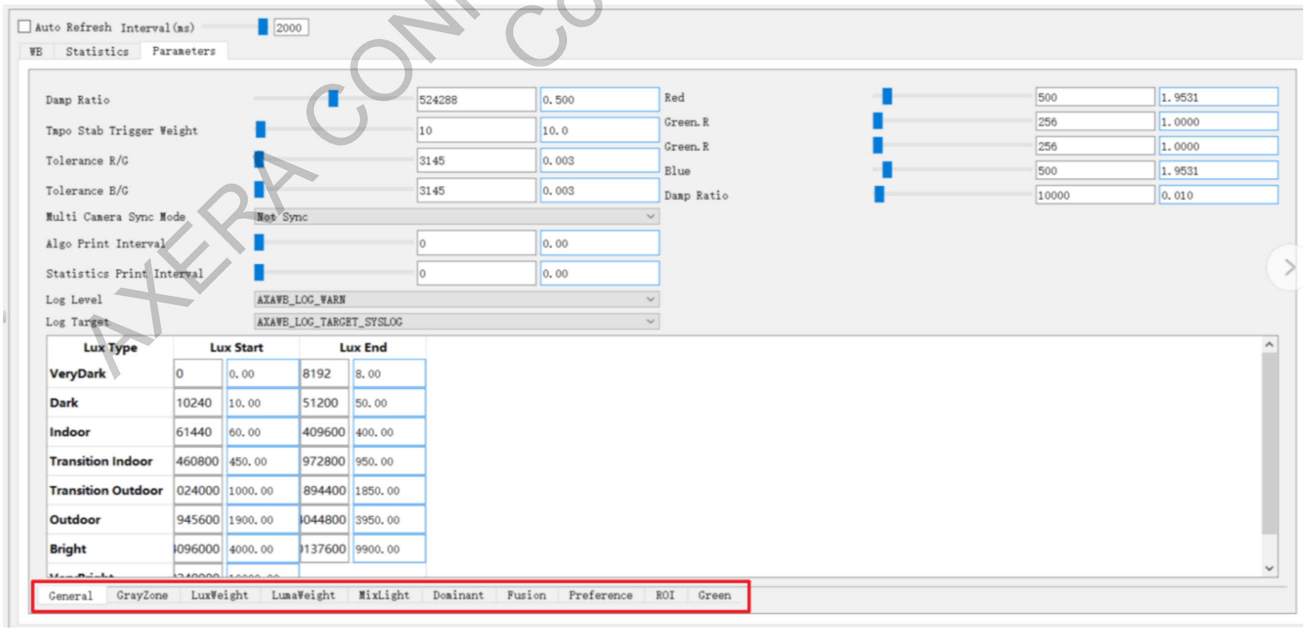


Figure 3-23 General Parameters

AWB parameters and strategies are located in the Parameters option box. They are divided into several sections: General, GrayZone, LuxWeight, LumaWeight, MixLight, Dominant, Fusion, Preference, ROI, and Green. The Statistics interface also includes the MLC strategy.

Strategy	Introduction Overview
Advanced Gray World	Compared to the basic Gray World, this includes five sub-strategies for more refined probability and preference control: Lux Weight, Luma, Dominant, MixLight, and Locus. Final Weight = Lux Weight × Luma Weight × Dominant Weight × MixLight Weight After obtaining the Final Weight, the weights of various statistical white points are known. After the weighting, the decision point is obtained. The decision point, after being adjusted by the Locus strategy, becomes the decision point for the advanced gray world.
Smoothing Strategy	Uses historical frames to smooth the white balance results to prevent flickering and abrupt changes.
Projection Strategy	To prevent color shifts in outdoor daylight, when the result of the Gray World algorithm falls to the left of the Planckian curve under high brightness, the result is projected onto the Planckian curve. Example: In outdoor daylight scenarios with an excess of green grass and trees and insufficient gray blocks, this feature can be activated to improve the purple-red tint in the image.
Illuminance Strategy	In different illuminance environments, the probability of gray objects appearing at various positions within the gray zone follows a certain pattern. Lux Weight indicates the probability of a block being a gray object under the current Lux.
Light and Dark Area	In typical indoor or outdoor scenes, windows with low Luma values may have noise, causing the r/g, b/g ratios to be less accurate than in brighter areas. Moreover, black

Preference Strategy	objects are not sensitive to color shifts, so a very low weight can be set. Additionally, overexposed areas may also have distorted r/g, b/g ratios, or non-white blocks like blue sky, so should also be assigned low weights. In dark scenes, where exposure may be maximized yet the image remains dark, many pixels are concentrated at low Luma levels, so a certain Luma weight is necessary to prevent AWB jumps.
Multi-Color Temperature Preference Strategy	Each statistical window has its own estimated color temperature. The standard deviation of color temperature can measure the dispersion of color temperature across windows, thereby assessing the probability of multiple color temperatures. The higher the multi-color temperature probability, the more severe the saturation attenuation. If a multi-color temperature scene is identified, different color temperature preferences can be configured for different brightness scenarios.
Dominance Preference Strategy	Mainly used to improve accuracy during objective testing, this strategy excludes interference from non-gray blocks in color cards when a dominant gray block is present. In scenarios like park monitoring, it also helps to exclude slight color changes in the background of the road caused by pedestrians in blue or yellow clothes entering and exiting.
Decision Point Fusion	Based on the weights and confidence of each Predictor, the decision points of each Predictor are fused.
Anchor Point Strategy	A strategy that directly predicts decision points based on Lux. Spatial refers to the R/G, B/G space. Example: In extremely bright environments where sunlight predominates, the spectrum and color temperature of sunlight are relatively fixed, allowing direct prediction of decision points. In outdoor scenarios with extensive blue sky and greenery where white objects are scarce, this decision point can provide a stable anchor.
Preference Strategy	Mainly used to adjust AWB according to your preferences, such as making low color temperature white blocks appear slightly yellow, more in line with human vision.

	Before adjusting preferences, ensure that the Fusion result can make white appear white, and do not attempt to solve the color shift problems of Fusion through preference adjustments, as this can lead to color shifts in other scenarios.
Green Zone Dynamic Segmentation Strategy	Excludes statistical points from green plants or green objects to prevent them from being miscounted as valid points, leading to AWB errors.
MLC Strategy	Excludes points that are likely to cause miscounting, such as indoor yellow objects or outdoor blue sky, retaining only valid gray points to improve statistical accuracy.

Description of ALG General Parameter

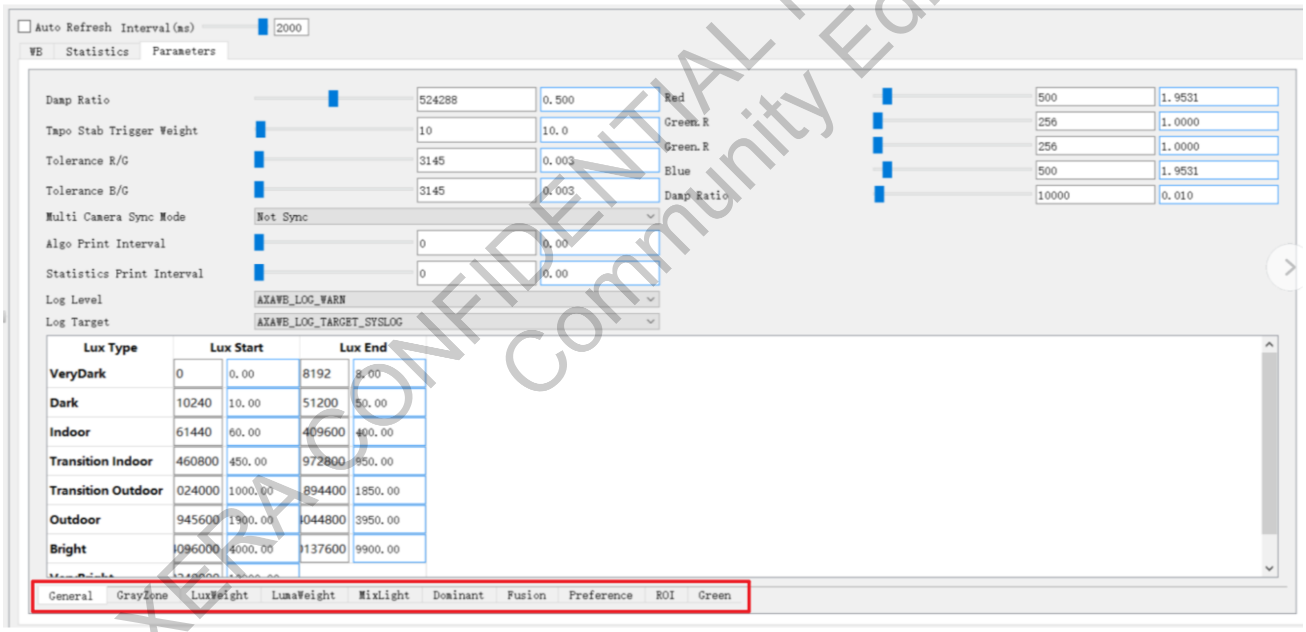


Figure 3-24 General Parameters

■ **Smoothing Strategy**

➢ Damp Ratio: White balance convergence speed. The closer to 0.0, the faster the convergence; the larger the value, the slower the convergence. Convergence Time in Seconds = [1/(1 - dampRatio)]/Frame Rate. For example, at a frame rate of 25 frames per second and a dampRatio of 0.99, the convergence time is 4 seconds = [1/(1 - 0.99)]/25.

- Tmpo Stab Trigger Weight: If the number of white blocks falling into the white zone is less than this value, the white point will not be changed. This means that the results from the current frame's gray world will not be used, and the decision point will remain based on the results when there are sufficient white points, preventing overall color changes due to intermittent presence of white points.
- Tolerance R/G: Changes to the White Balance Controller (WBC) hardware are made only when the current R/G ratio differs from the previous frame's R/G ratio by more than this threshold.
- Tolerance B/G: Changes to the WBC hardware are made only when the current B/G ratio differs from the previous frame's B/G ratio by more than this threshold.

■ Algorithm System

White balance differentiates scenes based on current illuminance (Lux). Currently supports distinction among eight types of scenes. The differentiation criteria are as follows:

Lux Type	Lux Start		Lux End	
VeryDark	0	0. 00	8192	8. 00
Dark	10240	10. 00	51200	50. 00
Indoor	61440	60. 00	09600	400. 00
Transition Indoor	60800	450. 00	72800	950. 00
Transition Outdoor	24000	1000. 00	94400	1850. 00
Outdoor	45600	1900. 00	44800	3950. 00
Bright	96000	4000. 00	37600	9900. 00
VeryBright	40000	10000. 00	-	

Figure 3-25 Scene

- VeryDark:

  Lux Start: Starting Lux value for the VeryDark illuminance level.

  Lux End: Ending Lux value for the VeryDark illuminance level.

- Dark:

Lux Start: Starting Lux value for the Dark illuminance level.

Lux End: Ending Lux value for the Dark illuminance level.

- Indoor:

  Lux Start: Starting Lux value for the Indoor illuminance level.

  Lux End: Ending Lux value for the Indoor illuminance level.

- Transition Indoor:

  Lux Start: Starting Lux value for the Transition Indoor illuminance level.

  Lux End: Ending Lux value for the Transition Indoor illuminance level.

- Transition Outdoor:

  Lux Start: Starting Lux value for the Transition Outdoor illuminance level.

  Lux End: Ending Lux value for the Transition Outdoor illuminance level.

- Outdoor:

  Lux Start: Starting Lux value for the Outdoor illuminance level.

  Lux End: Ending Lux value for the Outdoor illuminance level.

- Bright:

  Lux Start: Starting Lux value for the Bright illuminance level.

  Lux End: Ending Lux value for the Bright illuminance level.

- VeryBright:

  Lux Start: Starting Lux value for the VeryBright illuminance level.

Figure 3-26 Dual-camera Synchronization Mode

- Multi Camera Sync Mode: Dual camera synchronization mode. When set to “Not Sync”, each camera performs white balance calculations independently. When set to “Sync”, the two cameras work together to calculate white balance.

Gray Zone Division and Projection Strategy (GrayZone) Parameter Description

Gray Zone Division:

Gray Zone Split	Cct Threshold	
Inner Min CCt	2300	2300
Inner Max CCt	7800	7800
Outer Min CCt	1950	1950
Outer Max CCt	10000	10000
H to A	2800	2800
A to F	3300	3300
F to D5	4600	4600
D5 to D6	5600	5600
D6 to Shade	6600	6600

Figure 3-27 Gray Zone

The Gray Zone interface is divided into 24 small zones, along with several independent light sources. The parameters mentioned can adjust the shape of the gray zone as follows:

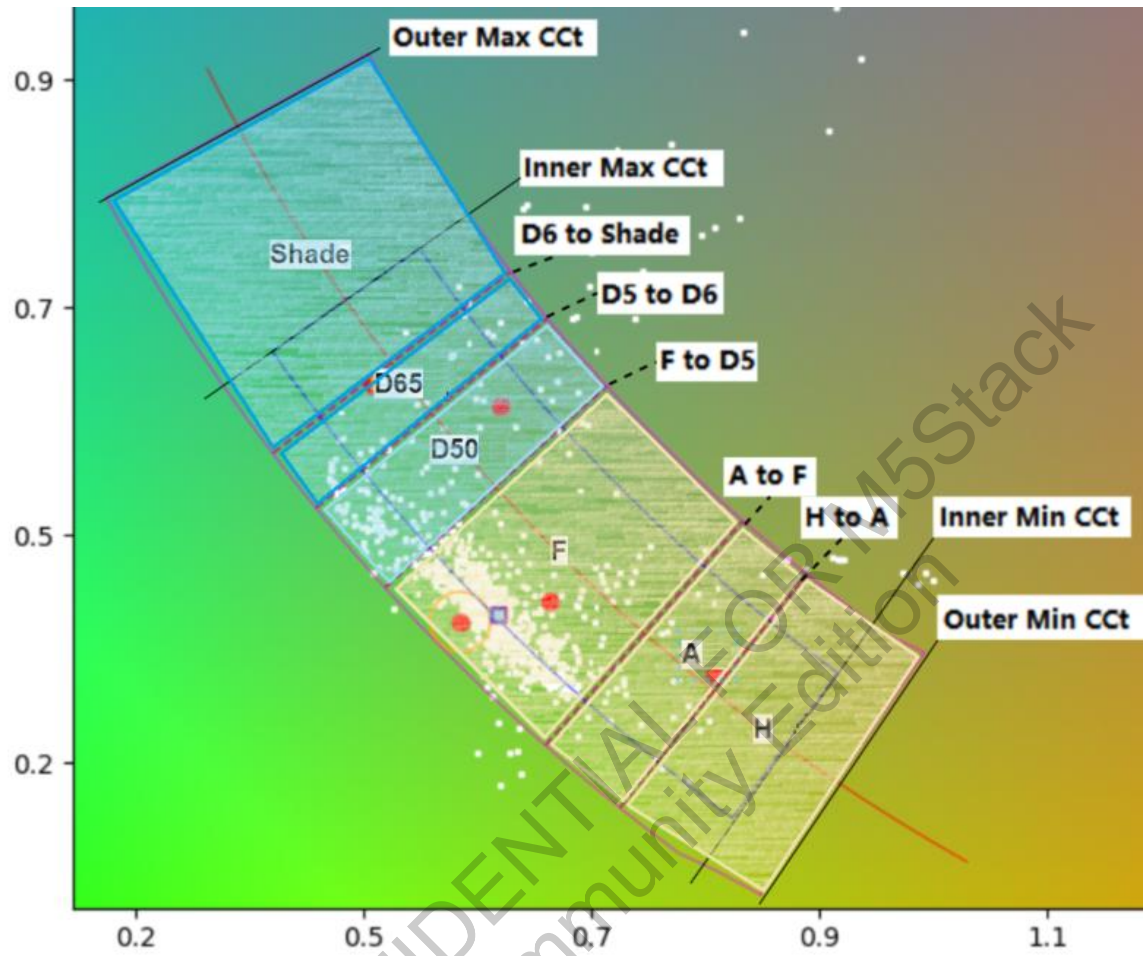


Figure 3-28 Gray Zone

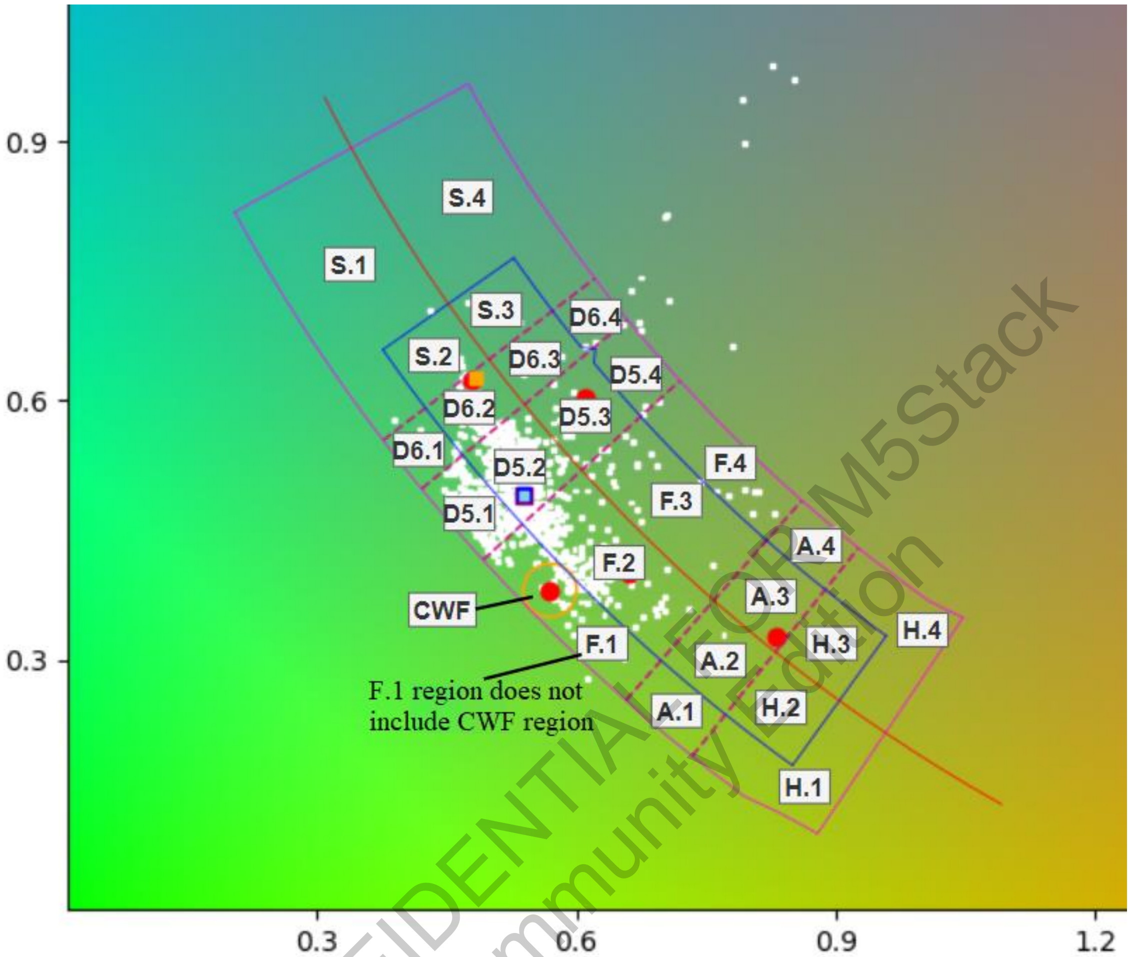


Figure 3-29 Small Gray Zone

During the debugging process, indoor light generally falls in Zone 1 (H.1 A.1 F.1 D5.1 D6.1 S.1). Extremely dark scenes may exhibit some degree of purple drift, which can be covered by Zone 4.

Projection Strategy

Planckian Locus Project in High Lux Scene		
Enable	☐	
Not Project Lux	4096000	4000.00
Full Project Lux	10240000	10000.00

Figure 3-30 Interface

- Enable: Strategy switch
- Not Project Lux: Below this Lux level, no projection is performed.
- Full Project Lux: Above this Lux level, full projection is performed.

Between these levels, interpolation projection is applied. The figure below shows the state of the gray zone with no projection, interpolation projection, and full projection.

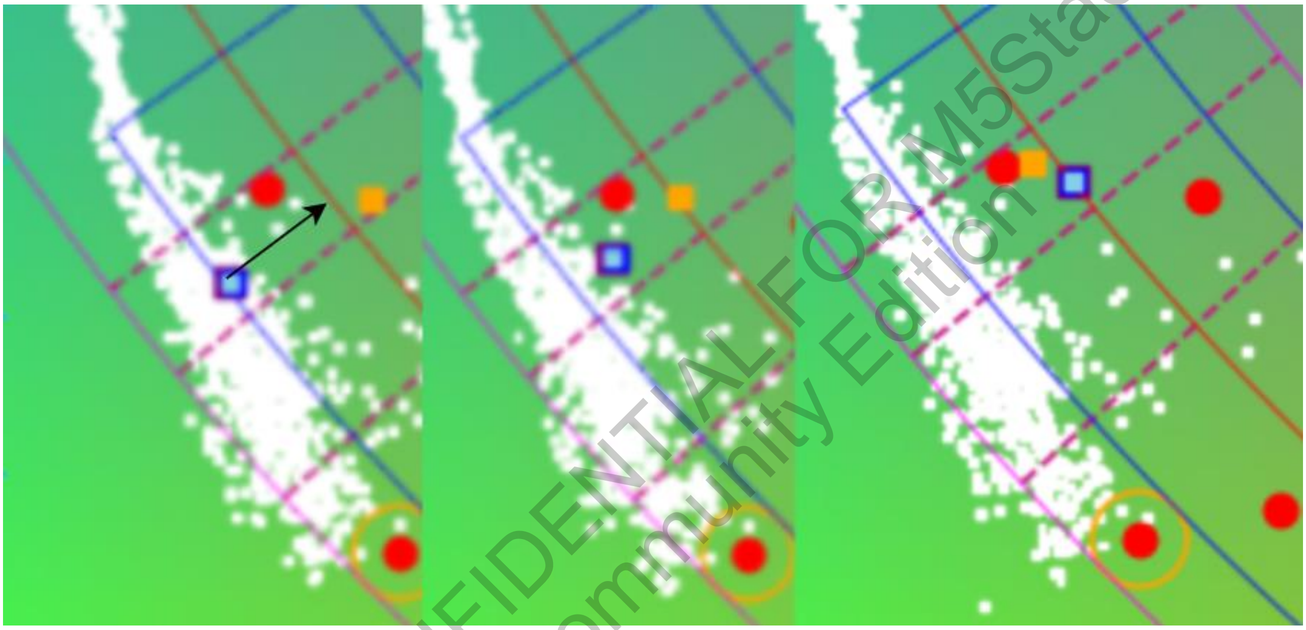
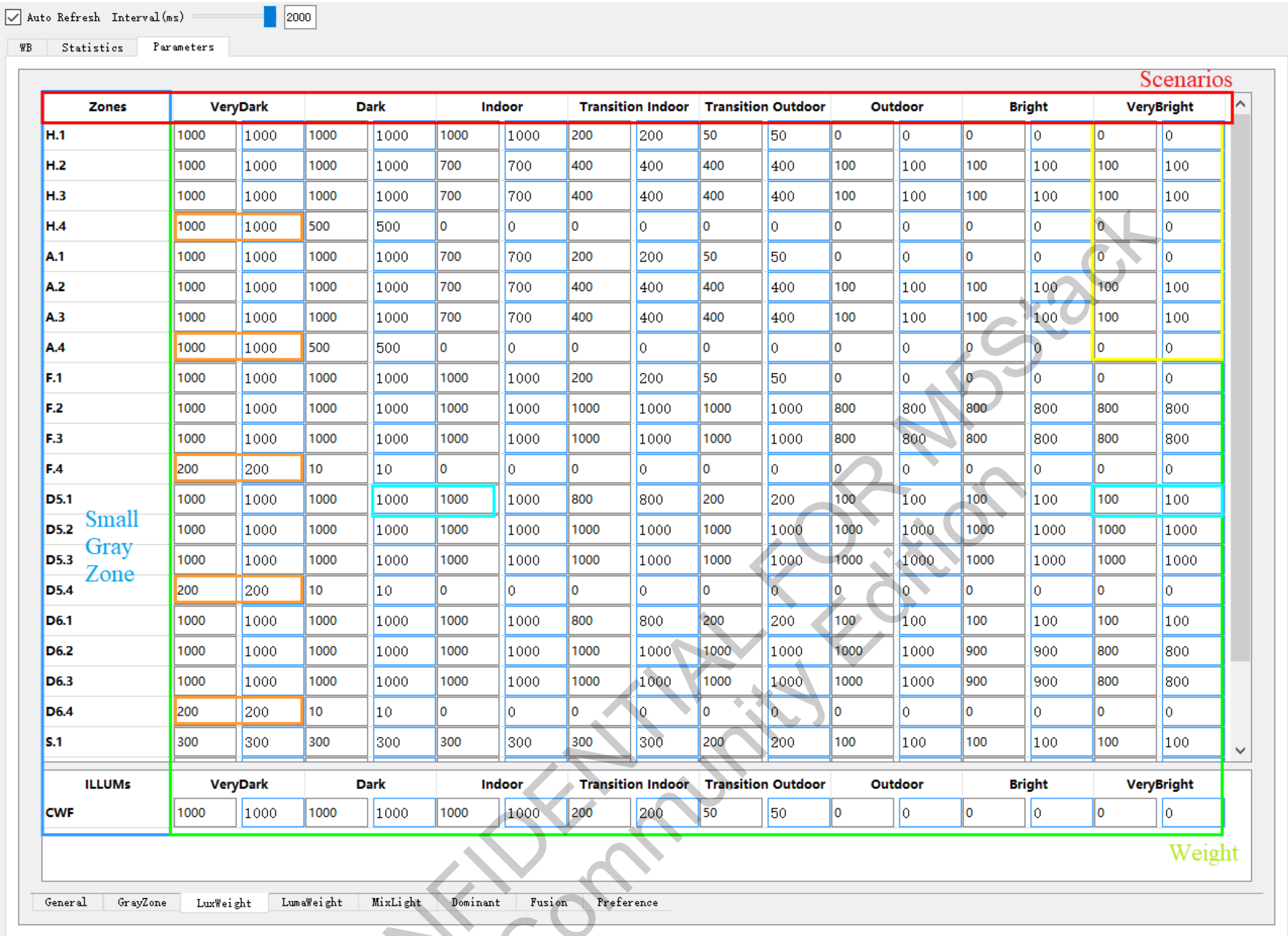


Figure 3-31 Projection Strategy

Illuminance Strategy (LuxWeight) Parameter Description



Zones	VeryDark		Dark		Indoor		Transition Indoor		Transition Outdoor		Outdoor		Bright		VeryBright	
H.1	1000	1000	1000	1000	1000	1000	200	200	50	50	0	0	0	0	0	0
H.2	1000	1000	1000	1000	700	700	400	400	400	400	100	100	100	100	100	100
H.3	1000	1000	1000	1000	700	700	400	400	400	400	100	100	100	100	100	100
H.4	1000	1000	500	500	0	0	0	0	0	0	0	0	0	0	0	0
A.1	1000	1000	1000	1000	700	700	200	200	50	50	0	0	0	0	0	0
A.2	1000	1000	1000	1000	700	700	400	400	400	400	100	100	100	100	100	100
A.3	1000	1000	1000	1000	700	700	400	400	400	400	100	100	100	100	100	100
A.4	1000	1000	500	500	0	0	0	0	0	0	0	0	0	0	0	0
F.1	1000	1000	1000	1000	1000	1000	200	200	50	50	0	0	0	0	0	0
F.2	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	800	800	800	800	800	800
F.3	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	800	800	800	800	800	800
F.4	200	200	10	10	0	0	0	0	0	0	0	0	0	0	0	0
D5.1	1000	1000	1000	1000	1000	1000	800	800	200	200	100	100	100	100	100	100
D5.2	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
D5.3	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
D5.4	200	200	10	10	0	0	0	0	0	0	0	0	0	0	0	0
D6.1	1000	1000	1000	1000	1000	1000	800	800	200	200	100	100	100	100	100	100
D6.2	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	900	900	800	800
D6.3	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	900	900	800	800
D6.4	200	200	10	10	0	0	0	0	0	0	0	0	0	0	0	0
S.1	300	300	300	300	300	300	300	300	200	200	100	100	100	100	100	100

ILLUMs	VeryDark		Dark		Indoor		Transition Indoor		Transition Outdoor		Outdoor		Bright		VeryBright	
CWF	1000	1000	1000	1000	1000	1000	200	200	50	50	0	0	0	0	0	0

Figure 3-32 LuxWeight

The Illuminance Strategy allows for the adjustment of gray zone weights in different brightness scenarios, enhancing the adaptability of white balance across scenes.

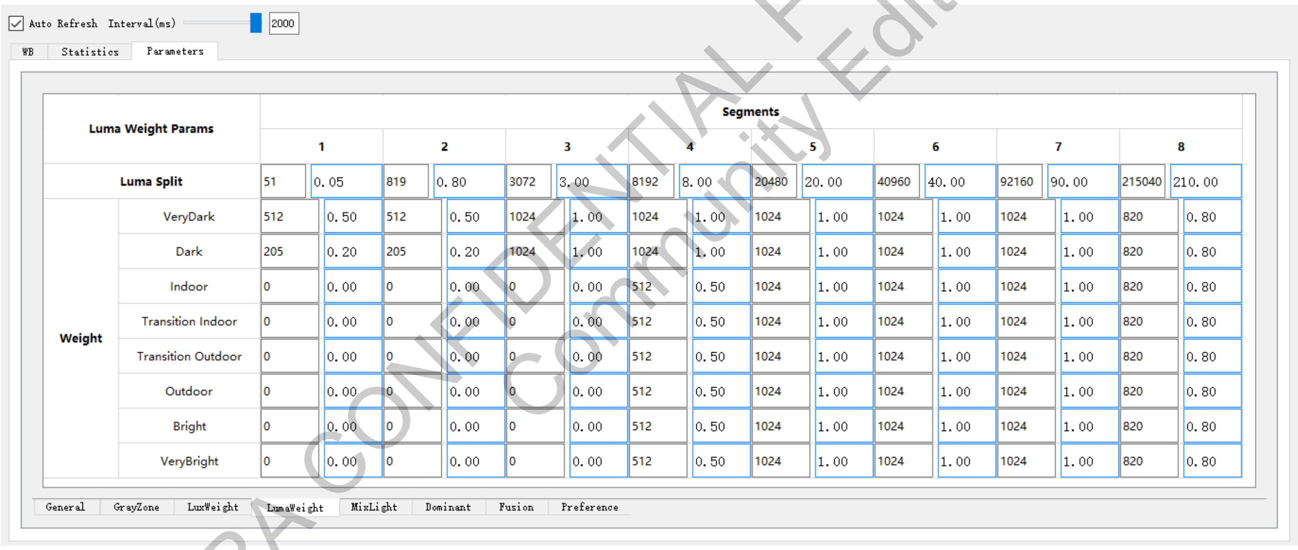
- The red box indicates the scene, and scene differentiation can refer to the “General Parameters” description.
- The green area represents the corresponding scene, where the weight of the statistical blocks falling into the small gray zone is indicated. Weights range from 0 to 1000.

Weights can be modified based on actual tuning experience. Examples:

- As indicated by the yellow box: In clear outdoor daylight (VeryBright scene), the weights for H.1-H4 A.1-A4 can be appropriately reduced because high-intensity sunlight rarely falls in the H and A zones. This adjustment can increase the accuracy of white balance for this scene.

- As shown in the orange box: In low-light scenes, where white points under low illuminance can exhibit purple drift, increasing the weight of the X.4 area can effectively prevent the image from turning purplish-red.
- As illustrated by the cyan box: Artificial light, compared to natural light, is closer to Zone 1. Therefore, for indoor scenes compared to outdoor scenarios, the weight of the X.1 area can be set higher to reflect this.

Brightness and Darkness Preference Strategy (LumaWeight) Parameter Description



Luma Weight Params		Segments															
		1		2		3		4		5		6		7		8	
Luma Split		51	0.05	819	0.80	3072	3.00	8192	8.00	20480	20.00	40960	40.00	92160	90.00	215040	210.00
Weight	VeryDark	512	0.50	512	0.50	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	820	0.80
	Dark	205	0.20	205	0.20	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	820	0.80
	Indoor	0	0.00	0	0.00	0	0.00	512	0.50	1024	1.00	1024	1.00	1024	1.00	820	0.80
	Transition Indoor	0	0.00	0	0.00	0	0.00	512	0.50	1024	1.00	1024	1.00	1024	1.00	820	0.80
	Transition Outdoor	0	0.00	0	0.00	0	0.00	512	0.50	1024	1.00	1024	1.00	1024	1.00	820	0.80
	Outdoor	0	0.00	0	0.00	0	0.00	512	0.50	1024	1.00	1024	1.00	1024	1.00	820	0.80
	Bright	0	0.00	0	0.00	0	0.00	512	0.50	1024	1.00	1024	1.00	1024	1.00	820	0.80
	VeryBright	0	0.00	0	0.00	0	0.00	512	0.50	1024	1.00	1024	1.00	1024	1.00	820	0.80

Figure 3-33 LumaWeight

In a scene, there are bright and dark areas. This strategy allows selection of which brightness areas in white balance statistics have a more significant impact. For example, in a typical outdoor scene, windows with low Luma values might have noise, causing inaccurate r/g, b/g ratios compared to brighter areas. Moreover, black objects are less sensitive to color shifts, so a lower weight can be assigned. Correspondingly, the weights for mid to high brightness areas can be freely adjusted as needed.

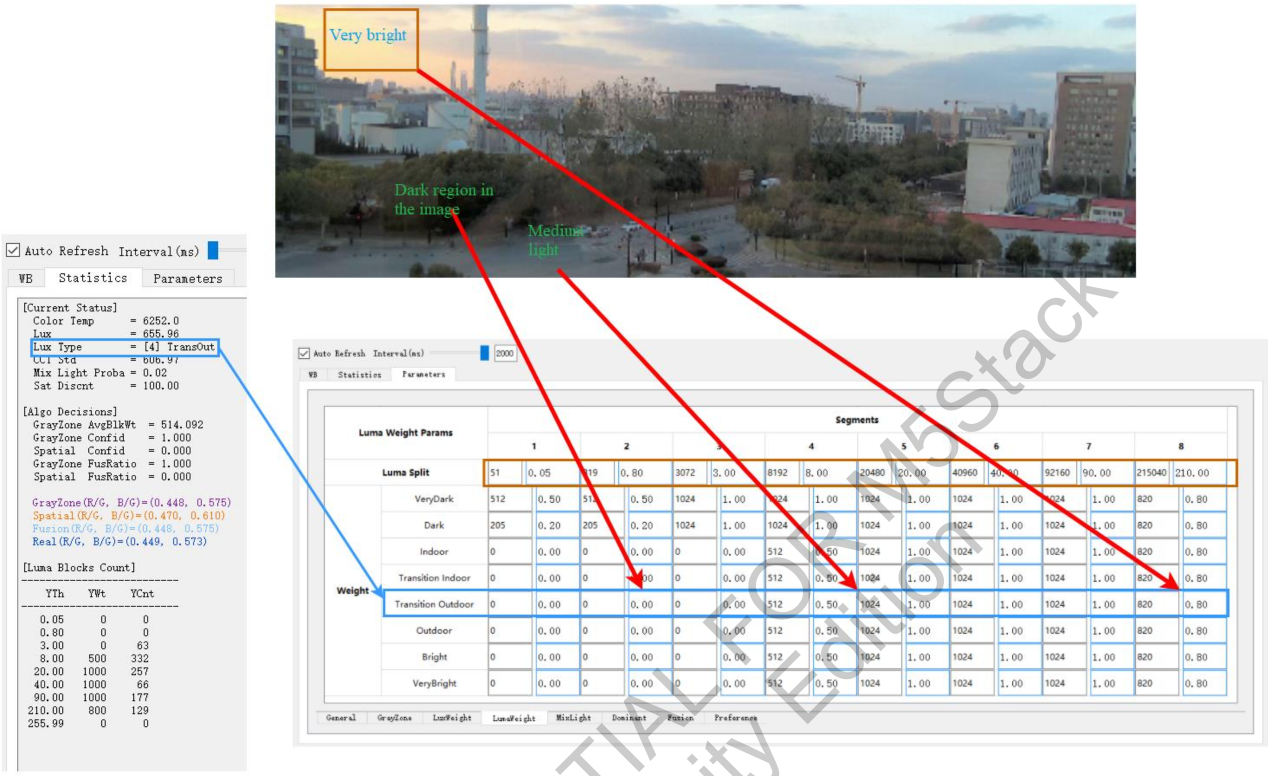
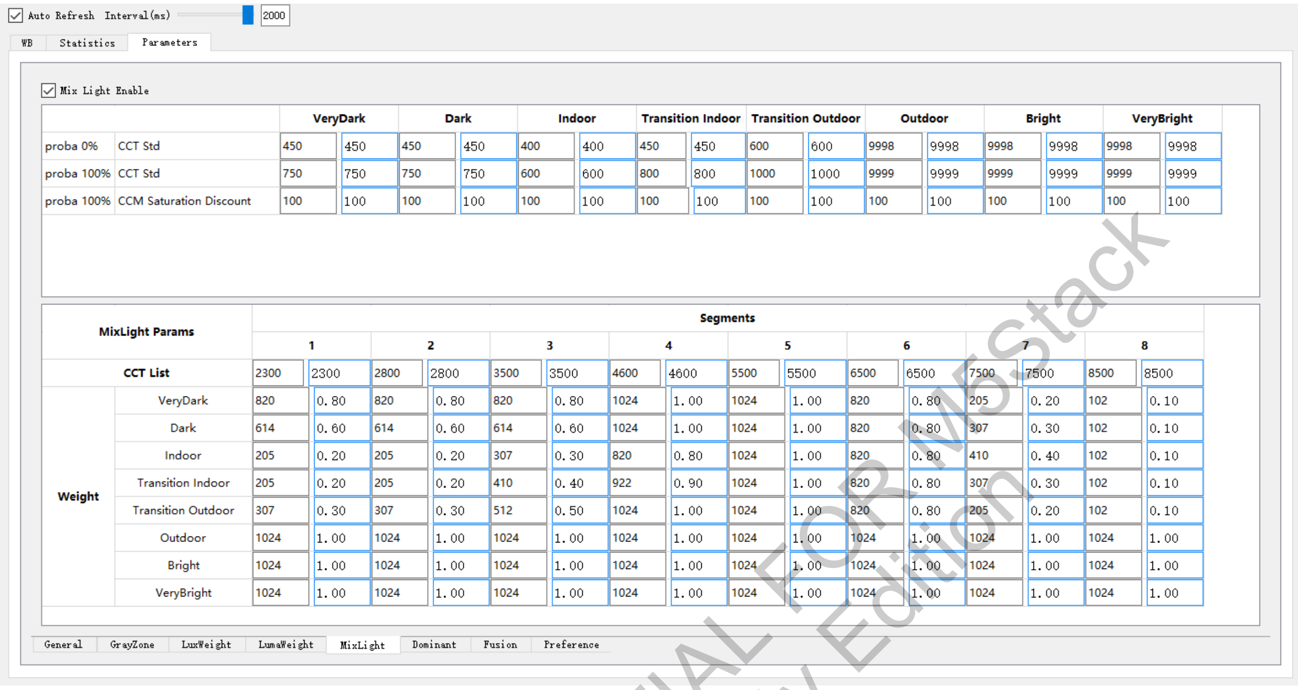


Figure 3-34 Debugging the Brightness and Darkness Area Strategy

Brightness and darkness are divided into eight levels. Threshold values between levels are configured in the Luma Split section, as shown in the orange box in the diagram above, and the weight configurations for bright and dark areas in different scenes are shown in the blue box. The meaning of parameters in the Statistics section are as follows:

- YTh: Brightness division threshold, corresponding to the number in the orange box in the diagram.
- YWt: Weight under that brightness, the higher the value, the higher the weight, corresponding to the number in the blue box.
- YCnt: Number of statistical points under that brightness.

Multi-Temperature Preference Strategy (MixLight) Parameter Description



		VeryDark		Dark		Indoor		Transition Indoor		Transition Outdoor		Outdoor		Bright		VeryBright	
proba 0%	CCT Std	450	450	450	450	400	400	450	450	600	600	9998	9998	9998	9998	9998	9998
proba 100%	CCT Std	750	750	750	750	600	600	800	800	1000	1000	9999	9999	9999	9999	9999	9999
proba 100%	CCM Saturation Discount	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

MixLight Params		Segments 1		2		3		4		5		6		7		8	
CCT List		2300	2300	2800	2800	3500	3500	4600	4600	5500	5500	6500	6500	7500	7500	8500	8500
Weight	VeryDark	820	0.80	820	0.80	820	0.80	1024	1.00	1024	1.00	820	0.80	205	0.20	102	0.10
	Dark	614	0.60	614	0.60	614	0.60	1024	1.00	1024	1.00	820	0.80	307	0.30	102	0.10
	Indoor	205	0.20	205	0.20	307	0.30	820	0.80	1024	1.00	820	0.80	410	0.40	102	0.10
	Transition Indoor	205	0.20	205	0.20	410	0.40	922	0.90	1024	1.00	820	0.80	307	0.30	102	0.10
	Transition Outdoor	307	0.30	307	0.30	512	0.50	1024	1.00	1024	1.00	820	0.80	205	0.20	102	0.10
	Outdoor	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00
	Bright	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00
	VeryBright	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00	1024	1.00

Figure 3-35 MixLight

Multi-temperature preference strategy calculates the standard deviation of color temperature through statistics, ultimately outputting multi-temperature preference weights and supporting attenuation of mixed light saturation. The strategy is as follows:

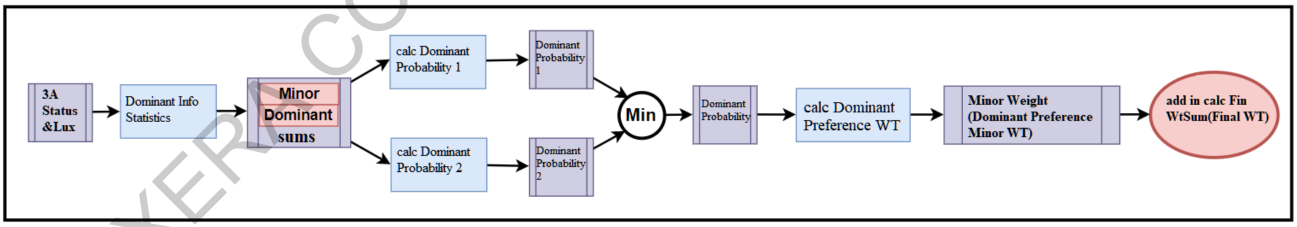


Figure 3-36 Multi-Color Temperature Preference Strategy

- Adjustments to the corresponding environmental settings of proba 0% CCT Std and proba 100% CCT Std can influence the multi-temperature probability.

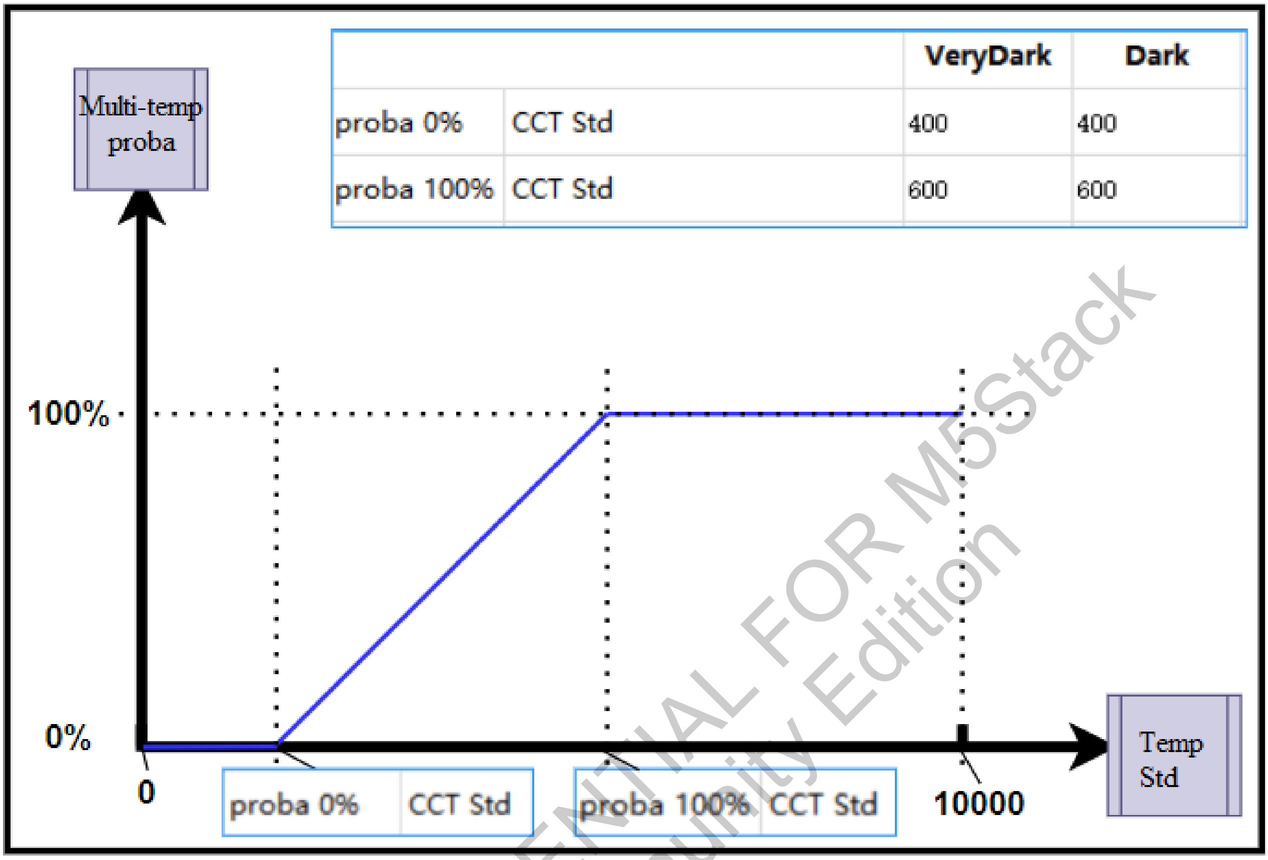


Figure 3-37 Multi-Temperature Probability Calculation

➢ Saturation attenuation calculation is shown in the figure below; modifying proba 100% CCM Saturation Discount can affect the Sat Discn (saturation attenuation value) and subsequently the CCM saturation:

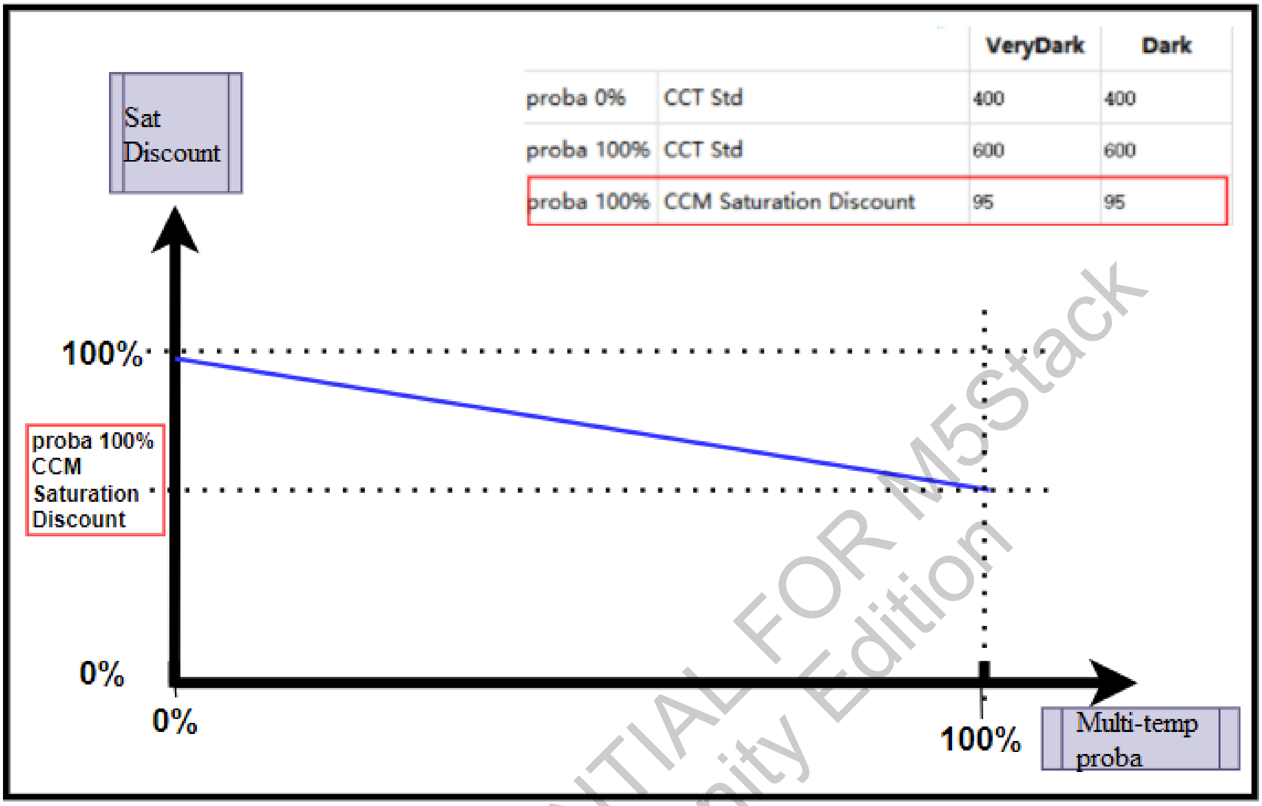


Figure 3-38 Saturation attenuation calculation:

- Multi-color temperature preference can be adjusted under any brightness scenario. For example, reducing the low-temperature weight in indoor scenes (shown in the green box) can help avoid color shifts caused by yellow objects.

MixLight Params		Segments																
		1		2		3		4		5		6		7		8		
CCT List		2300	2300	2800	2800	3500	3500	4600	4600	5500	5500	6500	6500	7500	7500	8500	8500	色温
Weight	VeryDark	820	0. 80	820	0. 80	820	0. 80	1024	1. 00	1024	1. 00	820	0. 80	205	0. 20	102	0. 10	权重
	Dark	614	0. 60	614	0. 60	614	0. 60	1024	1. 00	1024	1. 00	820	0. 80	307	0. 30	102	0. 10	
	Indoor	205	0. 20	205	0. 20	307	0. 30	820	0. 80	1024	1. 00	820	0. 80	410	0. 40	102	0. 10	
	Transition Indoor	205	0. 20	205	0. 20	410	0. 40	922	0. 90	1024	1. 00	820	0. 80	307	0. 30	102	0. 10	
	Transition Outdoor	307	0. 30	307	0. 30	512	0. 50	1024	1. 00	1024	1. 00	820	0. 80	205	0. 20	102	0. 10	
	Outdoor	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	
	Bright	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	
	VeryBright	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	1024	1. 00	

Figure 3-39 Multi-Color Temperature Preference Debugging

Dominant Preference Strategy (Dominat) Parameter Description

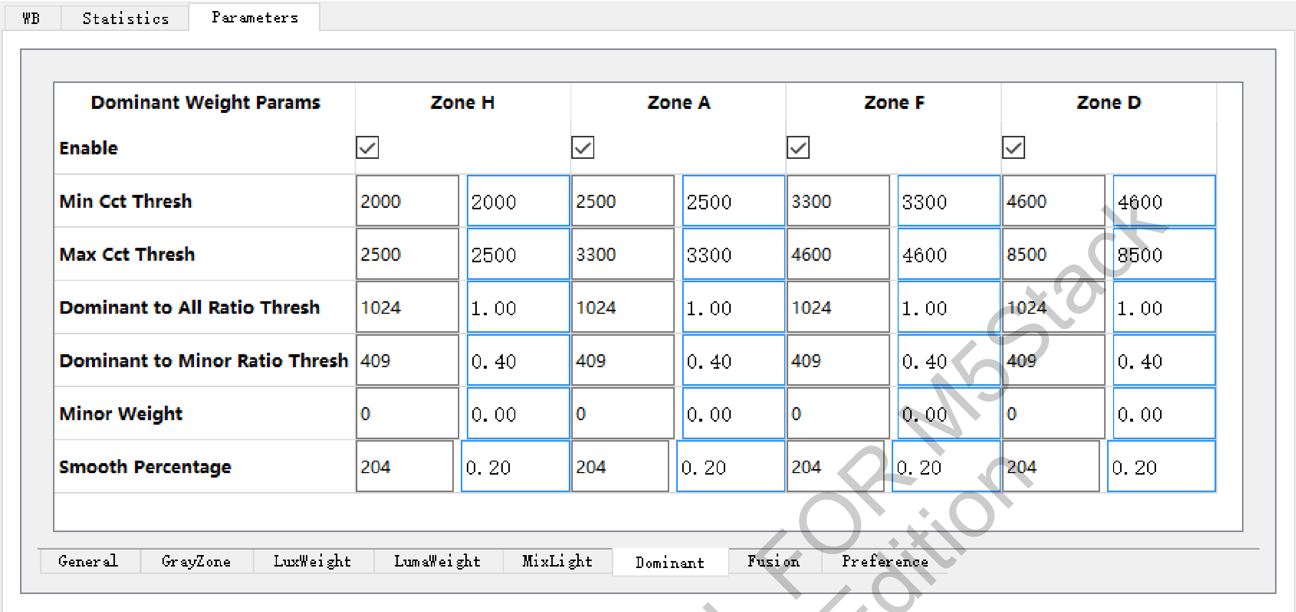


Figure 3-40 Interface

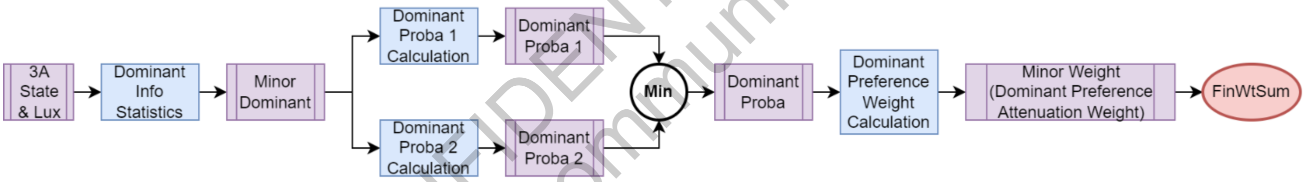


Figure 3-41 Strategy Flowchart

- **Dominant Area Drawing:**
  - Enable: Whether the dominant area is enabled, up to four areas can be configured: Zone H, A, F, D
  - Min Cct Thresh: Lower boundary of the dominant area
  - Max Cct Thresh: Upper boundary of the dominant area

  Each of the four dominant areas can be independently configured. For example, the dominant boundaries for Zone F are shown below.

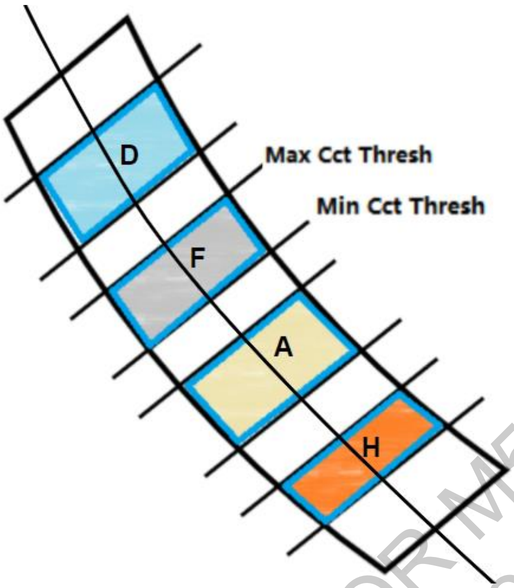


Figure 3-42 Four Dominant Areas

■ **Dominant Logic:**

Taking Zone F for example, all grey areas (ALL) are divided into dominant (Dominant) and non-dominant areas (Minor).

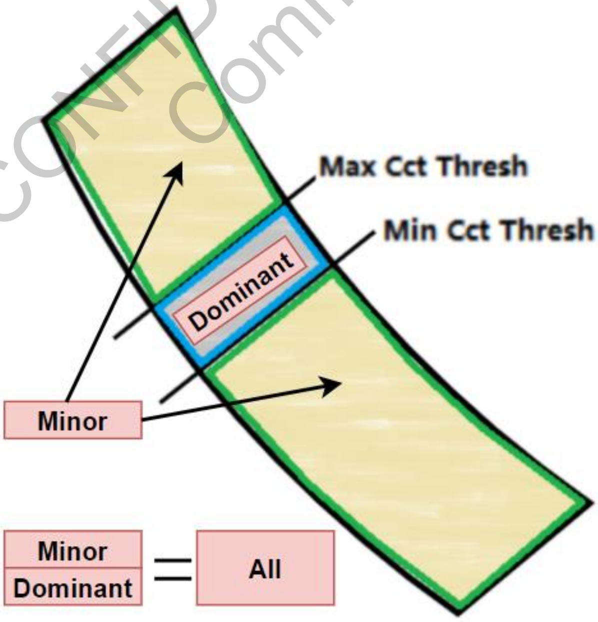


Figure 3-43 Dominant and Minor Areas

The smaller of the two calculated dominant probabilities, Dominant Probability 1 and Dominant

Probability 2, is taken as the final dominant probability.

The higher the Dominant to All Ratio Thresh and Dominant to Minor Ratio Thresh, the harder it is to be classified as having a high dominant probability. The higher the Smooth Percentage, the better the interpolation smoothing effect. Parameter debugging for calculating dominant probability 1 and 2 is shown below.

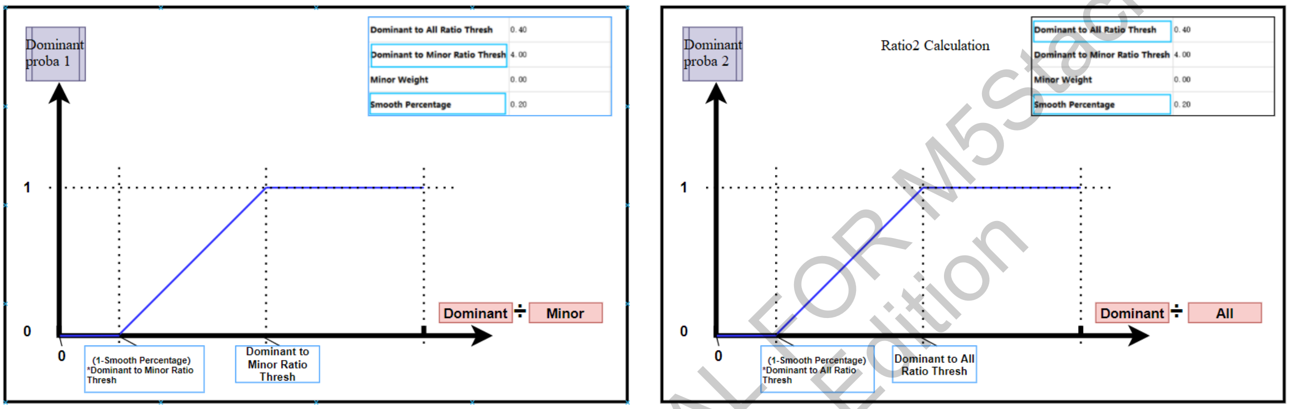


Figure 3-44 Dominant Probability 1 and 2 Calculation

The calculation method for dominant preference weights is shown in the diagram. The higher the Minor Weight, the less effective the dominant strategy.

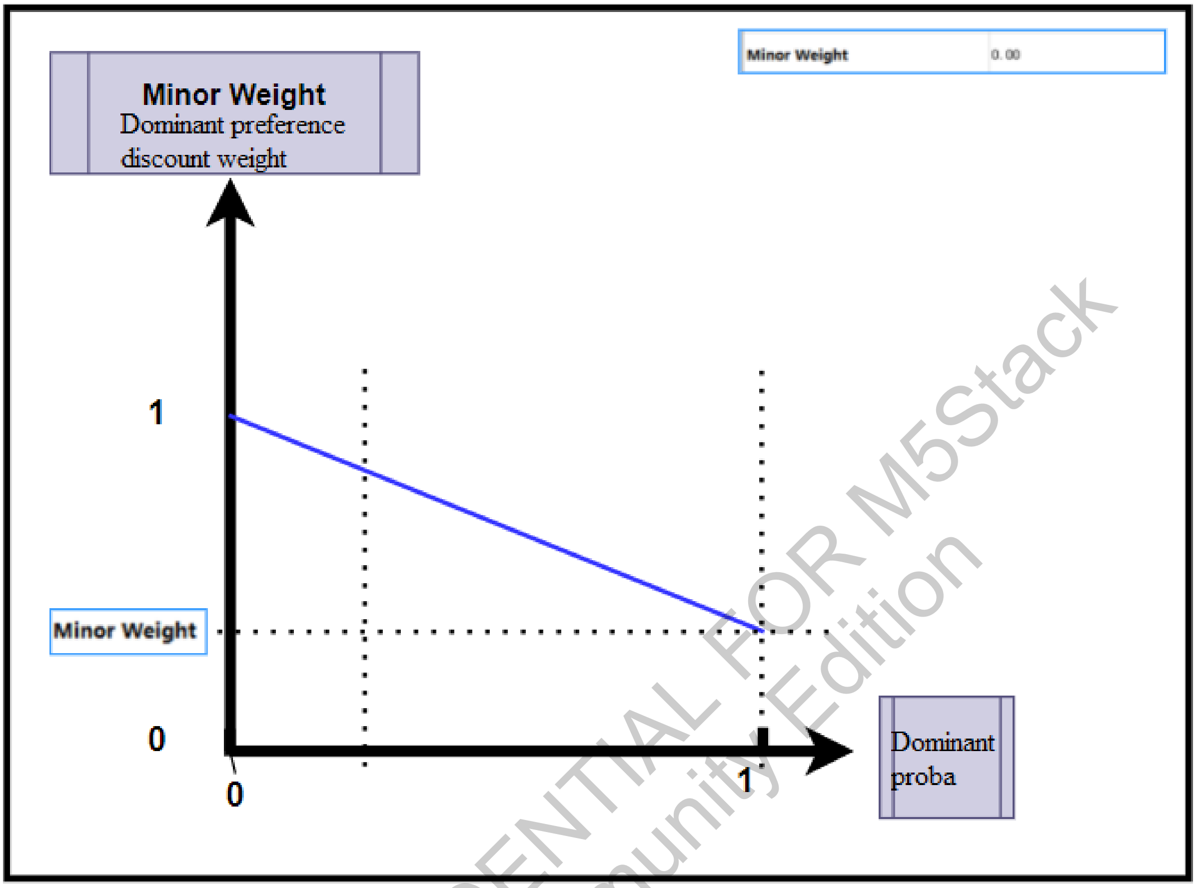


Figure 3-45 Dominant Preference Weight Calculation

Decision Point Fusion (Fusion) Parameter Description

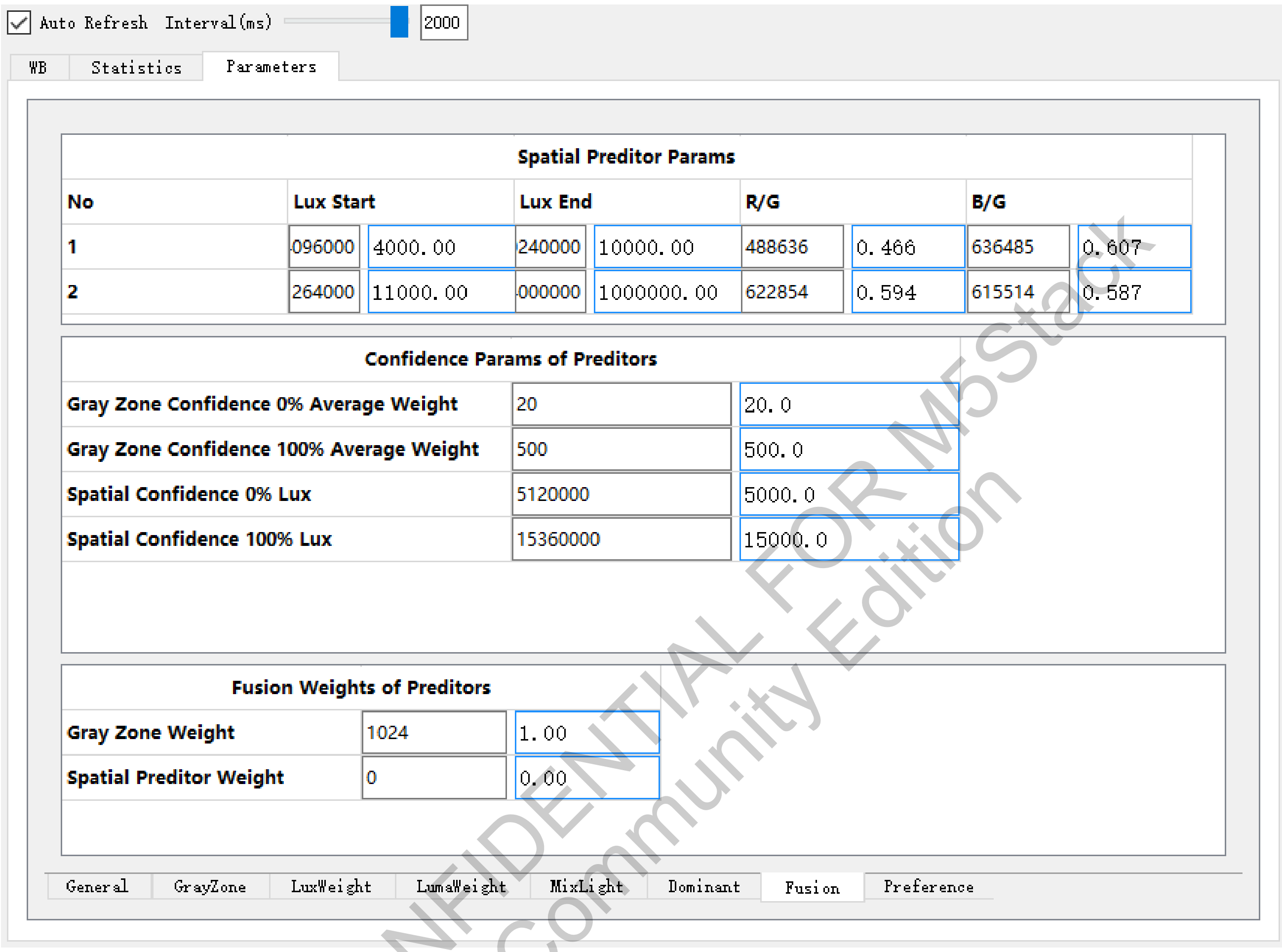


Figure 3-46 Interface

- **Algorithm logic:**

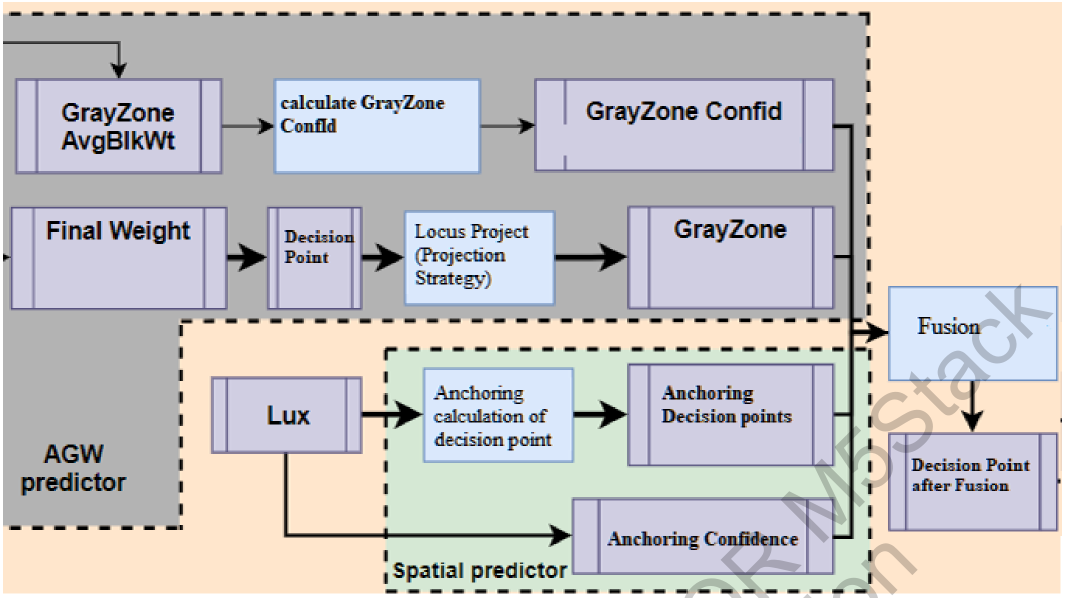


Figure 3-47 Decision Point Fusion Flowchart

- **Anchoring decision point calibration:**

Spatial Preditor Params								
No	Lux Start		Lux End		R/G		B/G	
1	096000	4000.00	240000	10000.00	488636	0.466	636485	0.607
2	264000	11000.00	000000	1000000.00	622854	0.594	615514	0.587

Figure 3-48 Anchoring Decision Point Calibration

Different brightness intervals can calibrate different anchoring decision points, using linear interpolation for differentiation.

For illuminance levels below the minimum, calculations are based on the minimum illuminance's anchoring decision point. For example, as shown above, No 1: 4000-10000 uses anchoring decision points 0.47 and 0.61. For environments with less than 4000 lux, the same anchoring decision points are used.

Similarly, for temperatures above the highest calibrated color temperature, the anchoring decision points of the highest calibrated temperature are used.

- Confidence Calculation

Confidence Params of Preditors		
Gray Zone Confidence 0% Average Weight	20	20.0
Gray Zone Confidence 100% Average Weight	500	500.0
Spatial Confidence 0% Lux	5120000	5000.0
Spatial Confidence 100% Lux	15360000	15000.0

Figure 3-49 Confidence Calculation

Advanced Gray World Confidence: If a high proportion of white points (statistical blocks) are concentrated in a gray area with a very high final weight. It is believed that there is high “confidence” in the advanced gray world.

If the calculated “confidence” is less than the Gray Zone Confidence 100% Average Weight, the confidence is considered to be 0%. If “confidence” exceeds the Gray Zone Confidence 100% Average Weight, the confidence is considered to be 100%. Intermediate values are linearly interpolated and smoothed.

Anchor Point Decision Confidence: If the illuminance (Lux) is less than Spatial Confidence 0% Lux, the anchor point decision confidence is considered to be 0%. If the illuminance (Lux) exceeds Spatial Confidence 100% Lux, the anchor point decision confidence is considered to be 100%.

- **Weight Calculation**

Fusion Weights of Preditors		
Gray Zone Weight	1024	1.00
Spatial Preditor Weight	0	0.00

Figure 3-50 Fusion Weight

- Gray Zone Weight: Gray scale weight, in cases where the confidence of the decision point in the advanced gray world is not 0, the higher this value, the closer the Fusion (post-fusion decision point) is to the decision point of the advanced gray world.
- Spatial Predictor Weight: Anchoring weight, in cases where the confidence of the anchoring decision point is not 0, the higher this value, the closer the Fusion (post-fusion decision point) is

to the anchoring decision point.

Fusion effect:

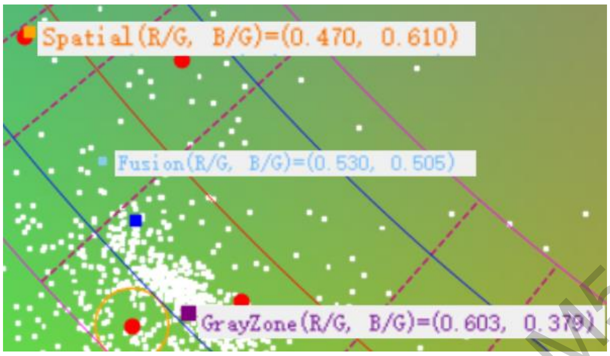


Figure 3-51 Strategy Effect

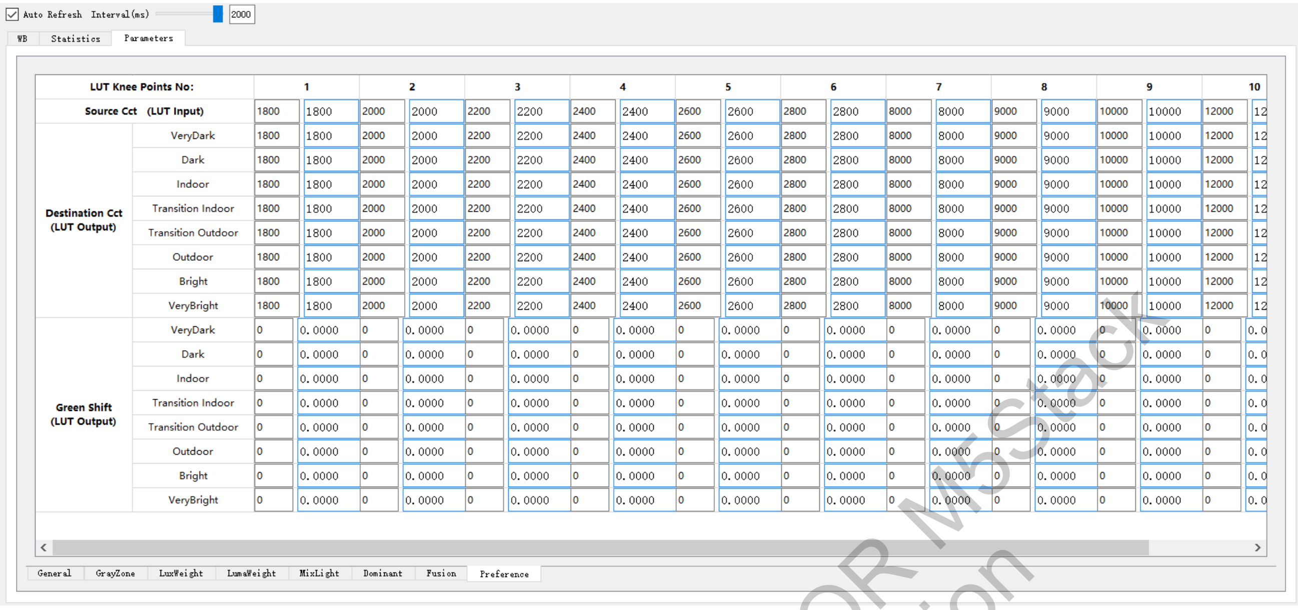
Preference Strategy (Preference) Parameter Description

! Note

It is strictly prohibited to use preference adjustments to solve issues with AWB color shifts. Remember the following rules:

To make white appear white, adjust the gray zone. (Prioritize adjusting the boundaries and weights of the gray zone to solve issues where white is not white enough)

To make white less white, adjust the preference. (Adjust preference only when white is already made white and you intentionally want it to appear less white)



LUT Knee Points No:		1		2		3		4		5		6		7		8		9		10	
Source Cct (LUT Input)		1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
Destination Cct (LUT Output)	VeryDark	1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
	Dark	1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
	Indoor	1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
	Transition Indoor	1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
	Transition Outdoor	1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
	Outdoor	1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
	Bright	1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
	VeryBright	1800	1800	2000	2000	2200	2200	2400	2400	2600	2600	2800	2800	8000	8000	9000	9000	10000	10000	12000	12
Green Shift (LUT Output)	VeryDark	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0
	Dark	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0
	Indoor	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0
	Transition Indoor	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0
	Transition Outdoor	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0
	Outdoor	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0
	Bright	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0
	VeryBright	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0000	0	0. 0

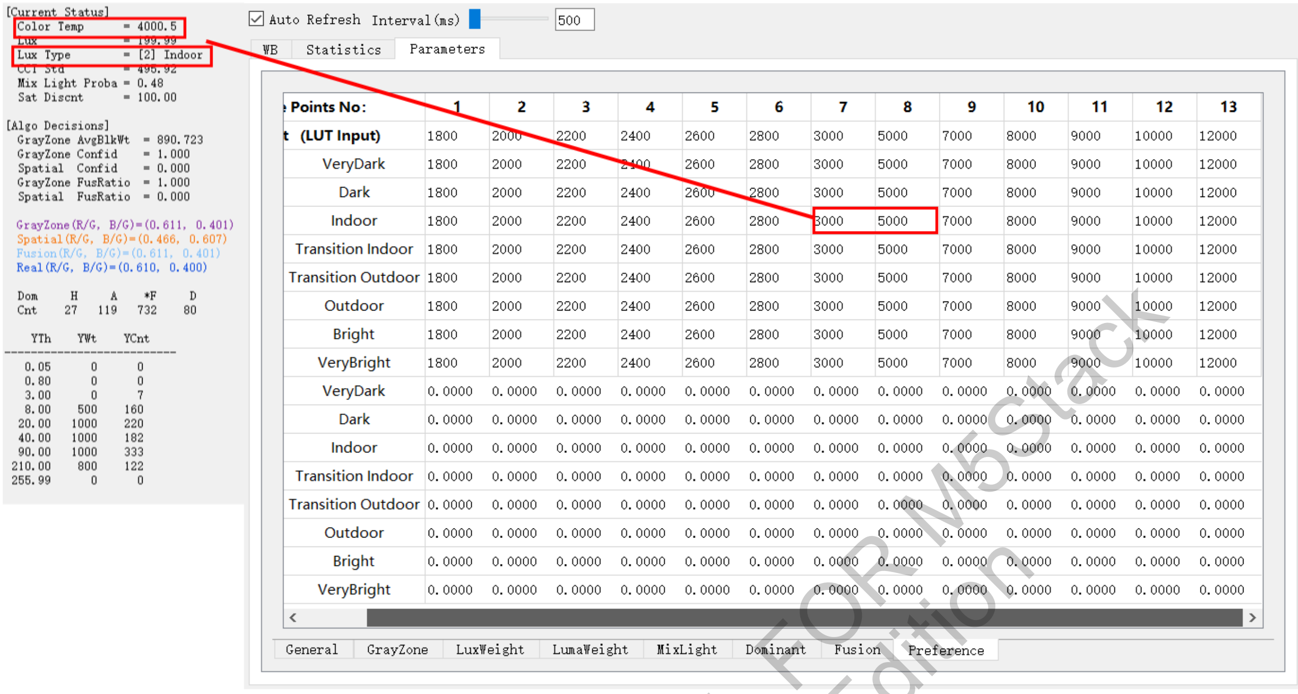
Figure 3-52 Interface

The preference strategy allows for vector movement of the Fusion (post-fusion decision point) under different illuminance and color temperature conditions. Movement is two-dimensional and can be combined to fine-tune the preferred color.

Especially note, before enabling preference settings, ensure that whites are made white. Do not use preference settings to adjust for color shifts.

- **Planckian Curve Direction:**

Translation operations along the Planckian curve direction. This operation can be independently adjusted under different illuminance and color temperatures. For example, in an indoor scene with a mixed color temperature around 4000K, you may wish to modify the white balance tone to be warmer or cooler. First, find the adjustable values under the corresponding illuminance and color temperature. As shown in the diagram, 4000K falls between 3000K and 5000K at indoor illuminance, corresponding to the red box on the right in the diagram below.



Points No:	1	2	3	4	5	6	7	8	9	10	11	12	13
t (LUT Input)	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
VeryDark	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
Dark	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
Indoor	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
Transition Indoor	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
Transition Outdoor	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
Outdoor	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
Bright	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
VeryBright	1800	2000	2200	2400	2600	2800	3000	5000	7000	8000	9000	10000	12000
VeryDark	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dark	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Indoor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Transition Indoor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Transition Outdoor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Outdoor	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bright	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
VeryBright	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Figure 3-53 Parameter Debugging Example

Increasing the values inside the red box will move the white point towards the lower color temperature area, resulting in a cooler tone, as shown in the left diagram. Decreasing the value has the opposite effect. The effects are detailed in the diagram below: the middle is unmodified. The left diagram prefers a cooler tone, and the right diagram prefers a warmer tone.

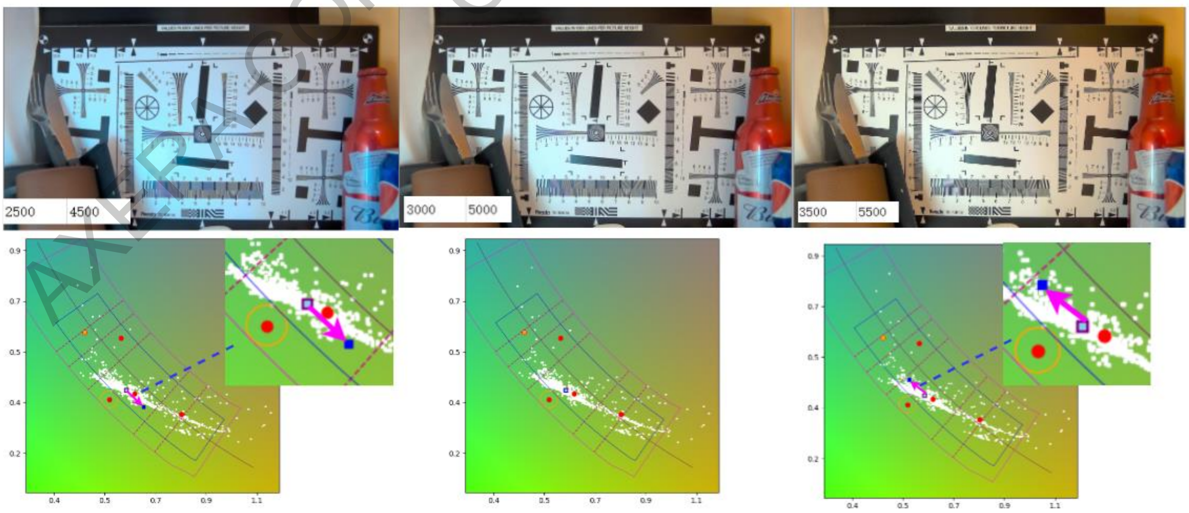


Figure 3-54 Modified Effect and White Point Changes

■ **Planckian Curve Vertical Direction:**

Translation operations in the vertical direction of the Planckian curve. This operation can be independently adjusted under different illuminance and color temperatures. For example, in an indoor scene with a mixed color temperature around 4000K, you may want to modify the white balance green/magenta preference. First, find the adjustable values under the corresponding illuminance and color temperature. As shown in the diagram, 4000K falls between 3000K and 5000K at indoor illuminance, corresponding to the red box on the right in the diagram below.

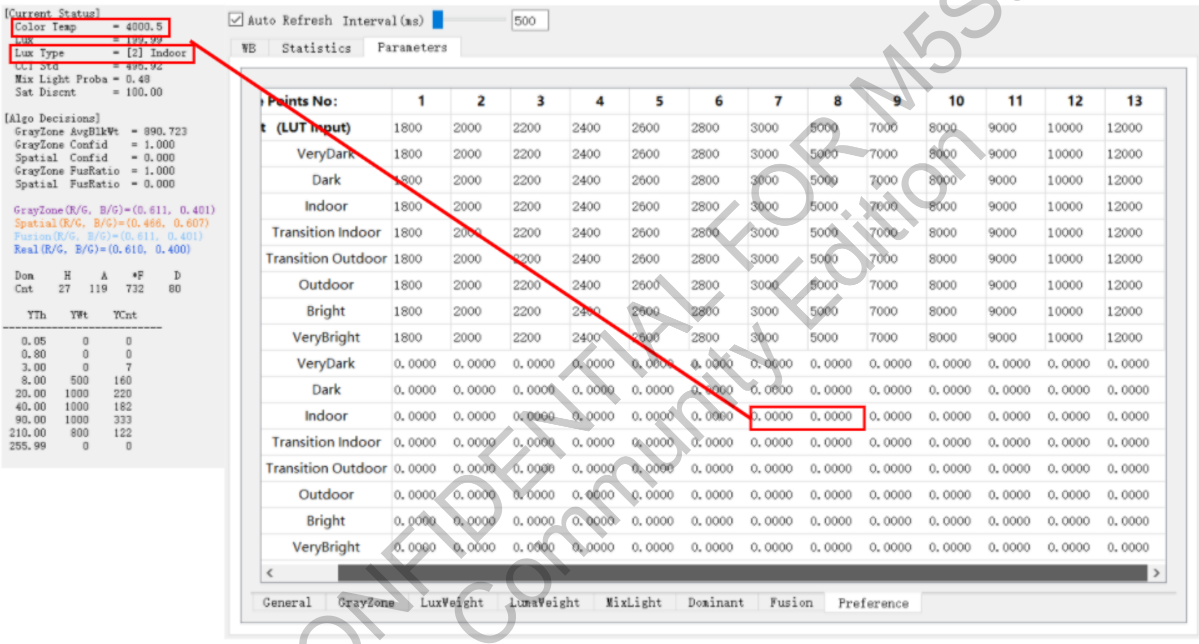


Figure 3-55 Parameter Debugging Location Example

Increasing the values inside the red box will move the white point towards the green area, resulting in a magenta bias, as shown in the left diagram. Decreasing the value has the opposite effect. The effects are detailed in the diagram below: the middle is unmodified. The left diagram is slightly magenta, and the right diagram is slightly green. Both types of shifts can be combined to achieve the desired white point shift.

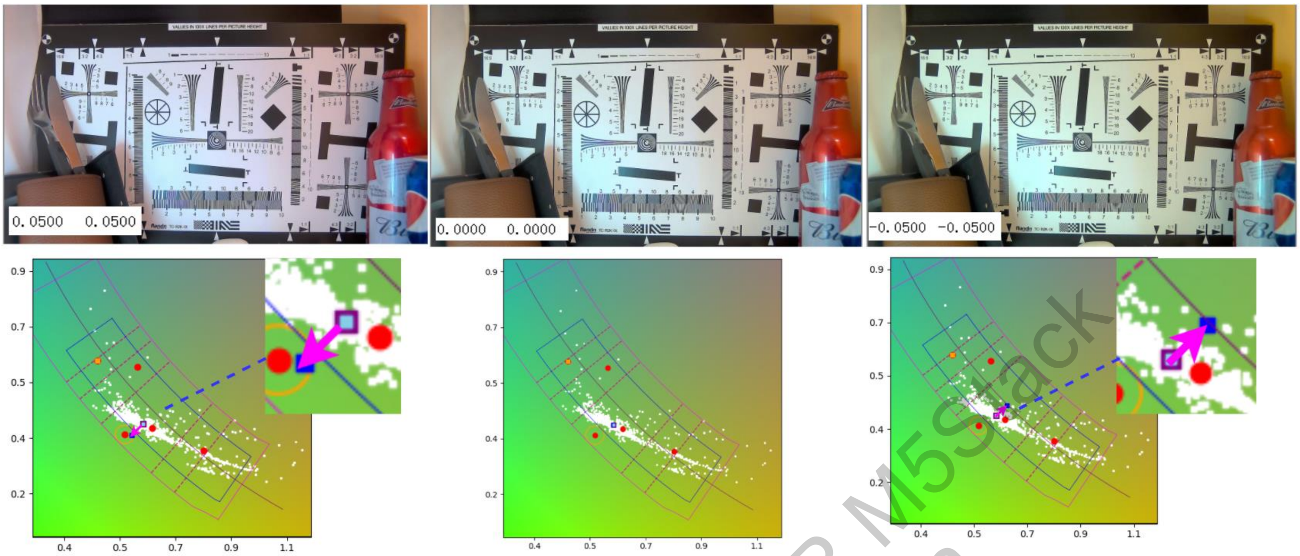


Figure 3-56 Adjusting Values Inside the Red Box

Green Zone Dynamic Segmentation Strategy (Green) Parameter Description

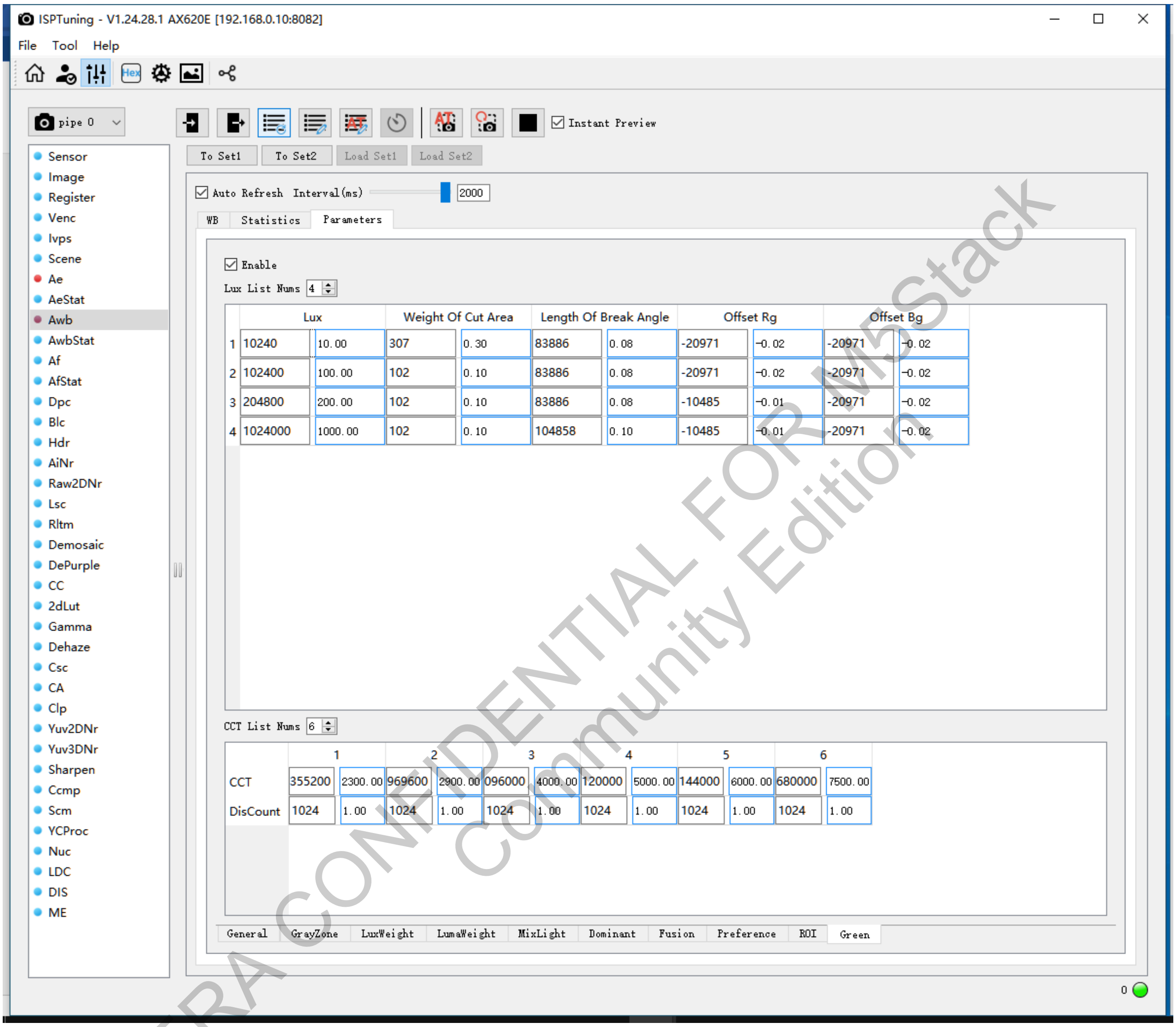


Figure 3-57 Green Zone Dynamic Segmentation Debugging

In scenes that include green areas, both indoors and outdoors, green statistical points often fall within the F light statistics area, leading to deviations in the final AWB statistical points. The dynamic green zone cutting strategy is implemented by setting a specific area to contain these green points and reducing their statistical weight to ensure the accuracy of the AWB points calculated. The area composed of three line segments in the lower left part of the figure below represents the green cutting zone.

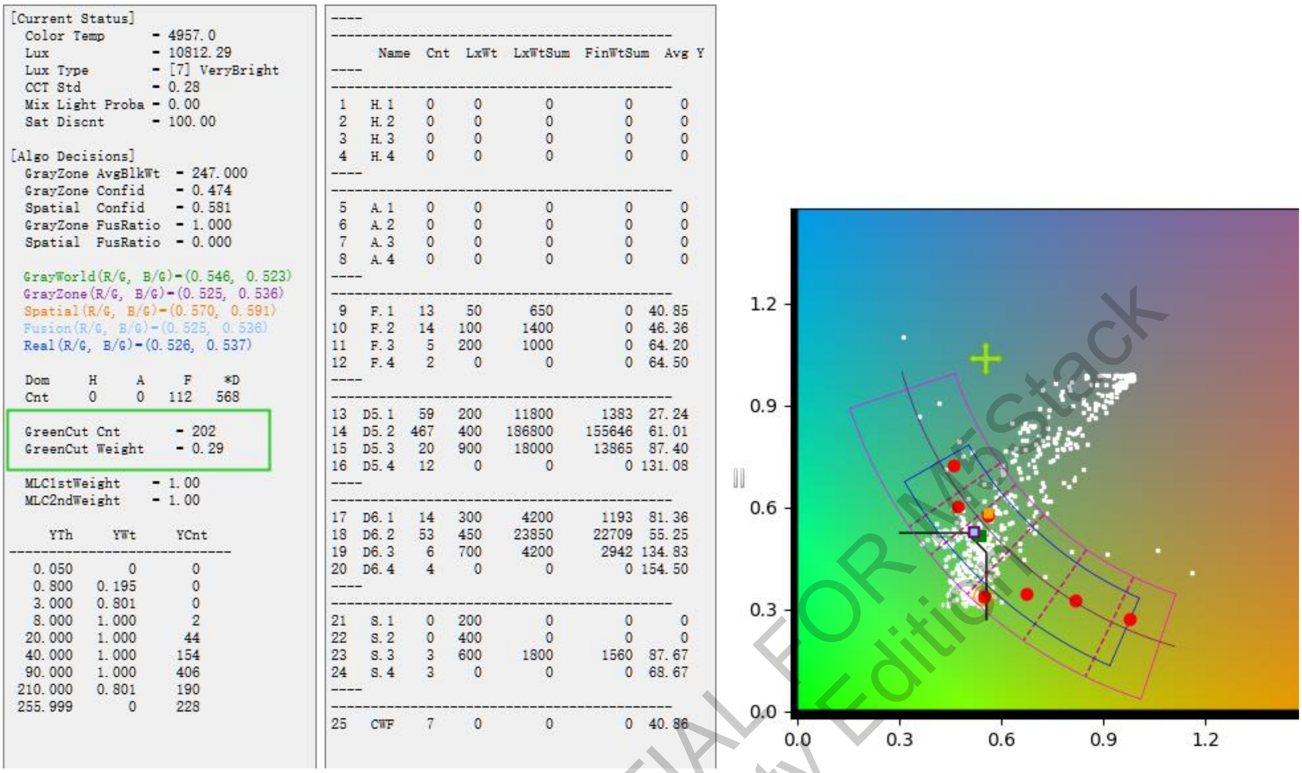


Figure 3-58 Green Zone Dynamic Segmentation Region

Statistical Information

GreenCut Cnt: The number of statistical points within the GreenCut removal area.

GreenCut Weight: The attenuation weight within the GreenCut removal area.

Parameter Description

Enable: Toggle switch for enabling dynamic cutting in the green area.

Lux List Nums: The number of active lux parameters, supporting up to 8 sets. Each set can have its CutArea and attenuation weight set separately. Linear interpolation is performed between two sets.

Lux: The lux threshold for the current set.

Weight of Cut Area: The lux attenuation weight of the statistical points within the cut area, ranging from 0 to 1; when set to 1, GreenCut is ineffective, and 0 indicates full attenuation. It is recommended not to set this to 0. In some special scenarios, due to statistical point deviations, the cutting frame might encompass the entire statistical area, and setting it to 0 would result in no effective statistical points.

Length of Break Angle: Controls the length and position of the cutting area's diagonal side; the higher the value, the longer the diagonal.

Offset Rg: Controls the position of the right boundary of the cutting area; can be a negative value, the smaller the value, the more the right boundary shifts left.

Offset Bg: Controls the position of the upper boundary of the cutting area; can be a negative value, the smaller the value, the lower the upper boundary moves.

! Note: The three edges of the green zone will move with the movement of GrayWorld statistical points.

CCT List Nums: The number of currently effective CCT parameters, with support for up to 8 sets.

CCT: CCT parameter threshold, which must be set in ascending order.

DisCount: Attenuation weight for the statistical points within the cut area, ranging from 0 to 1. When set to 1, GreenCut is ineffective; 0 means full attenuation.

! When either the lux attenuation weight or CCT attenuation weight is set to 1, GreenCut will not be effective.

! When both weights are less than 1, the final attenuation weight is calculated as the product of the lux attenuation weight and the CCT attenuation weight.

Debugging Strategy

In scenes with green areas, finely adjust the position of the green cutting area to ensure that as many green plant statistical points are included as possible while avoiding the erroneous cutting of valid statistical points. The AWB Stat frame can be used to assist in adjusting by selecting green areas, as shown in the diagram below. The purple area within the statistical frame indicates the selected green point locations, and the area composed of three slanted lines represents the green cutting zone, the weight of which can be configured through the Weight of Cut area and DisCount setting.

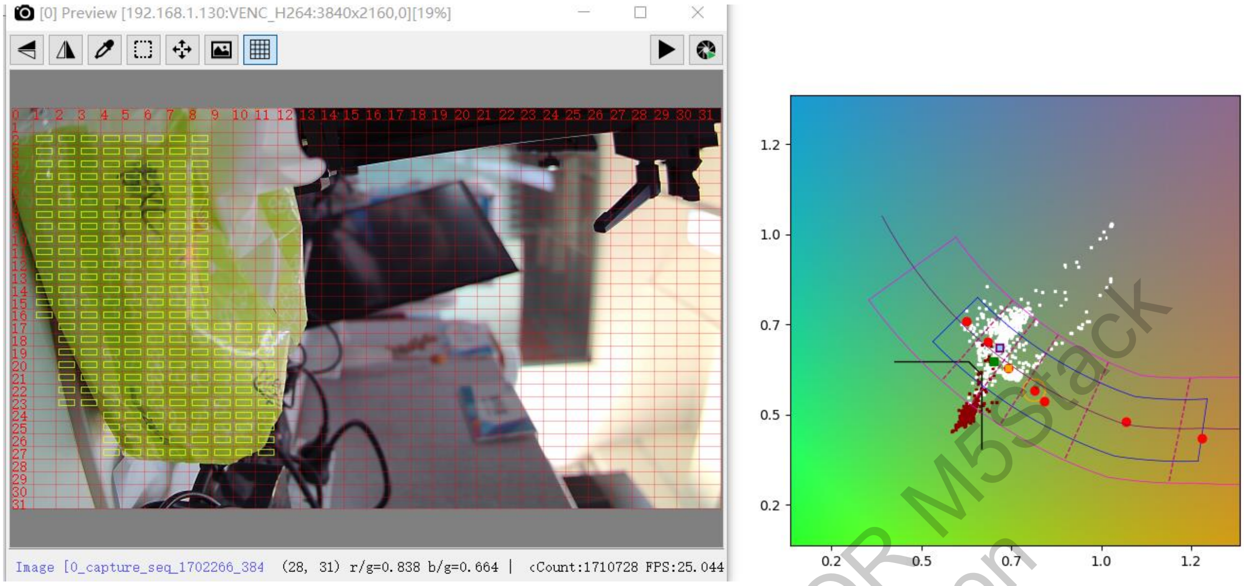


Figure 3-59 Green Zone Dynamic Cutting Statistical Point Example

MLC Strategy Parameter Description

Certain special colors, such as yellow objects indoors or blue skies outdoors, may fall within the statistical area in some scenes, causing deviations in AWB statistics. The MLC strategy aims to enhance the accuracy of AWB statistics by enclosing these special colors within a specified area (either rectangular or triangular) within the statistical region. Points that fall into this area are considered invalid and do not contribute to the AWB statistics.

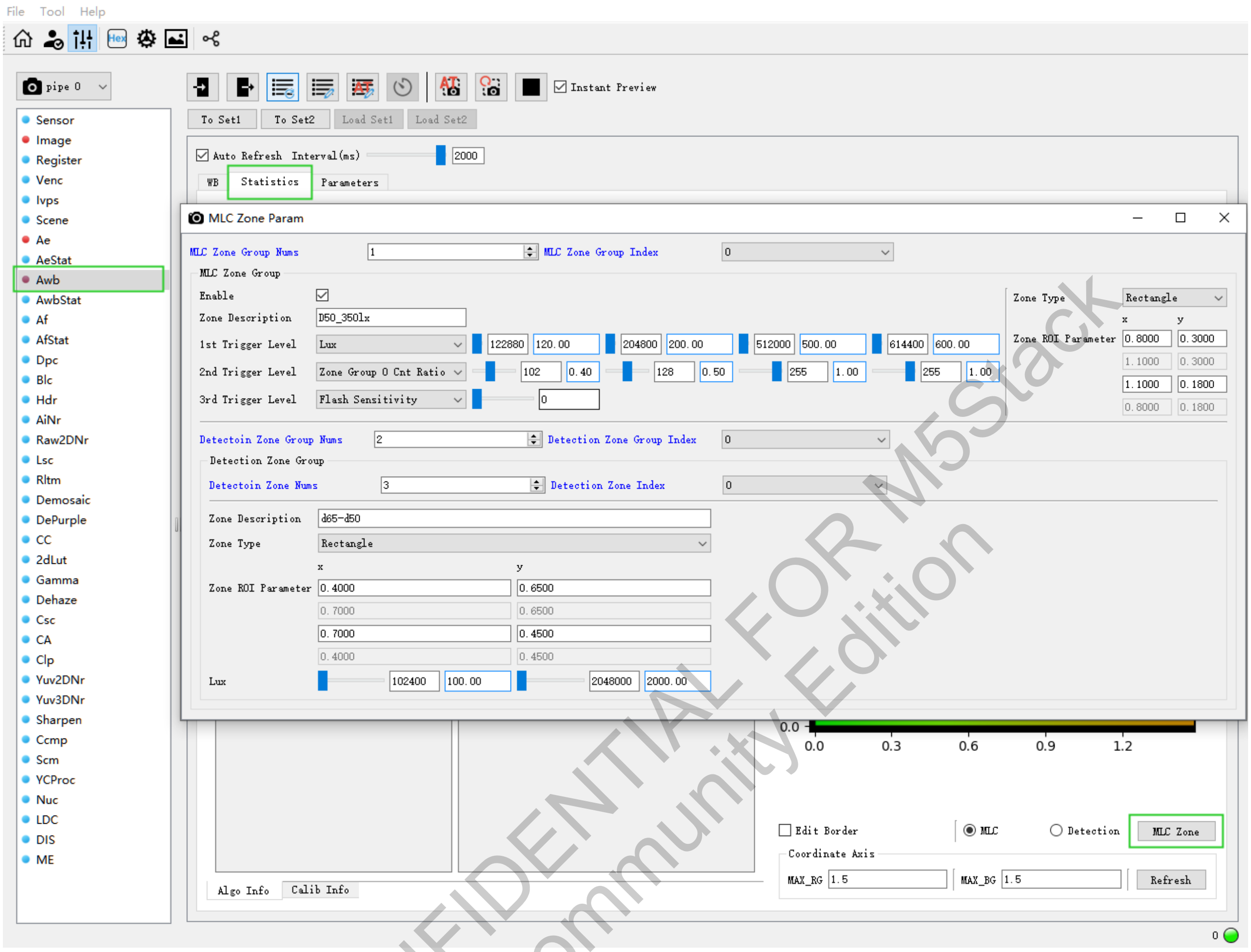


Figure 3-60 MLC Debugging

Parameter Description

MLC Zone Group Nums: Number of MLC Zones, ranging from 0 to 15 and up to 16.

MLC Zone Group Index: Current Displayed Index Value of MLC Zone

- For example, if MLC Zone Group Nums = 2, MLC Zone Group Index would automatically be set to 0 and 1.

  When MLC Zone Group Nums = 2, two sets of parameters can be configured; Index 0 represents one set, and Index 1 represents another.

Enable: Toggle switch for the MLC Zone feature.

Zone Description: When the number of MLC Zones is large, add descriptions for each MLC Zone for easier review.

1st Trigger Level: Condition 1 for using the MLC feature to eliminate false detection points. This includes various Trigger Values for you to choose from. Each trigger value contains four thresholds, representing [lower limit - transition area, lower limit, upper limit, upper limit + transition area]. Note: The four thresholds must be set in ascending order.

- Lux: The range of Lux values effective for triggering the MLC, with the four values representing the starting and ending Lux, and the upper and lower transition areas.
- CCT: The range of CCT values effective for triggering the MLC, with the four values representing the starting and ending Lux, and the upper and lower transition areas.
- Valid Stats Cnt Ratio: The ratio of statistical points within the gray area to the total number of points, with the four values representing the starting and ending ratio, and the upper and lower transition areas.
- Agw Rg: The range of Rg values effective for triggering the MLC, with the four values representing the starting and ending ratio, and the upper and lower transition areas.
- Agw Bg: The range of Bg values effective for triggering the MLC, with the four values representing the starting and ending ratio, and the upper and lower transition areas.
- Zone Group [i] Cnt Ratio: Specifies the detection zone ratio range for triggering MLC functionality, used in conjunction with detection zone configurations, allowing for multiple groups.

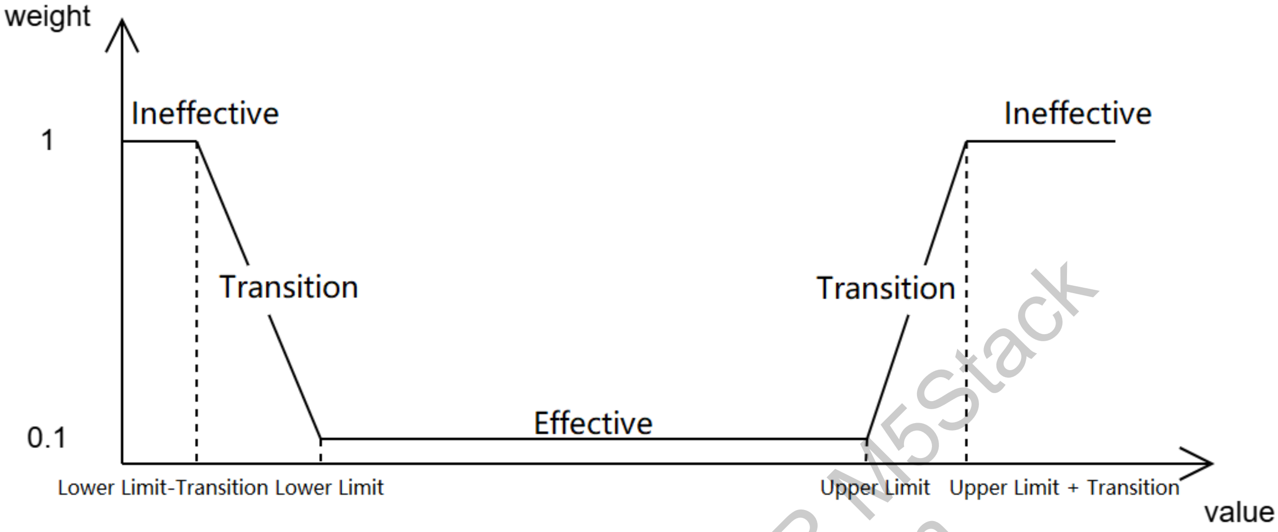


Figure 3-61 Methods for Trigger Value Taking Effects

2nd Trigger Level:

- Similar to the 1st Trigger Value, used for excluding false detection points under additional conditions.

3rd Trigger Level:Flash Sensitivity:

- Conditions for using the MLC feature to exclude false detection points in scenarios involving flash usage. Set to 0 to disable, 1 to enable, kept disabled in security applications.

Zone Type: Shape of the MLC Zone, supporting either Rectangle or Triangle.

Zone ROI Parameter: Endpoint coordinates of the MLC Zone area.

- If Rectangle is chosen, it represents the coordinates of two diagonal points of the rectangle.
- If Triangle is chosen, it represents the coordinates of the three points of the triangle.
- Supports manual framing; after selecting a rectangular or triangular area, you can draw the frame by dragging the mouse on the statistical area interface.

Detection Zone Group Nums: Number of detection zone groups. Value range: [0, 10].

Detection Zone Group Index: Index of the detection zone groups.

- For example, if Detection Zone Group Nums = 2, Detection Zone Group Index would automatically be set to 0 and 1.

  Two sets of parameters can be configured; Index 0 represents one set, and Index 1 represents another.

Detection Zone Nums: Number of detection zones. Value range: [0, 5].

Detection Zone Index: Index of the detection zones.

☞ Within each Detection Zone Group, 1 to 5 sets of Detection Zones can be set separately. If the Cnt Ratio of any one Detection Zone meets the condition, it can trigger the Trigger value.

Zone Description: When the number of Detection Zones is large, add descriptions for easier review.

Zone Type: Shape of the Detection Zone,

- supporting either Rectangle or Triangle.
- Supports manual framing; after selecting a rectangular or triangular area, you can draw the frame by dragging the mouse on the statistical area interface.

Zone ROI Parameter: Endpoint values of the Detection Zone area:

- If Rectangle is chosen, it represents the coordinates of two diagonal points of the rectangle.
- If Triangle is chosen, it represents the coordinates of the three points of the triangle.

Lux: Lux range in which the Detection Zone is effective.

The Detection Zone is shown as a blue rectangular frame, and the MLC Zone as a red rectangular frame in the debugging interface.

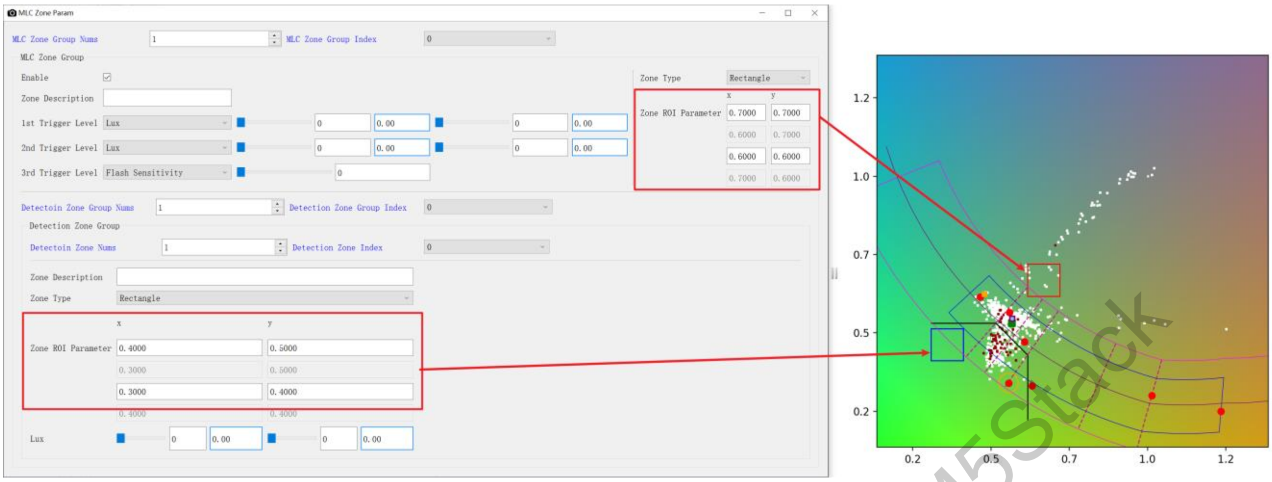


Figure 3-62 MLC Debugging

Debugging Strategy

- MLC Zone Groups can be used in conjunction with Detection Zone Groups or independently.
- A Detection Zone Group serves as a condition for an MLC Zone Group to be effective.
- Common triggers for activating MLC include Lux/CCT/Zone Group Cnt Ratio.

Common debugging strategies:

- In D50/D65/D75 color temperature environments, when there are many detection points and high illuminance, it is possible to exclude certain yellow monochrome object detection points or directly exclude areas below 3500k in gray zones to ensure common scenes like indoors or daylight do not exhibit color bias.
- Under indoor lighting, in CWF/TL84 situations where there are many detection points, you might trim areas below 2800k in color temperature to ensure large indoor yellow scenes do not exhibit color bias.
- In indoor lighting scenarios, you can calibrate detection points for specific colors like blue, yellow, and green, and make minimal trims.
- In outdoor scenes above 10,000 lux, you can calibrate and trim blue sky detection points.

3.3.4 Statistical Information

Statistical information Overview

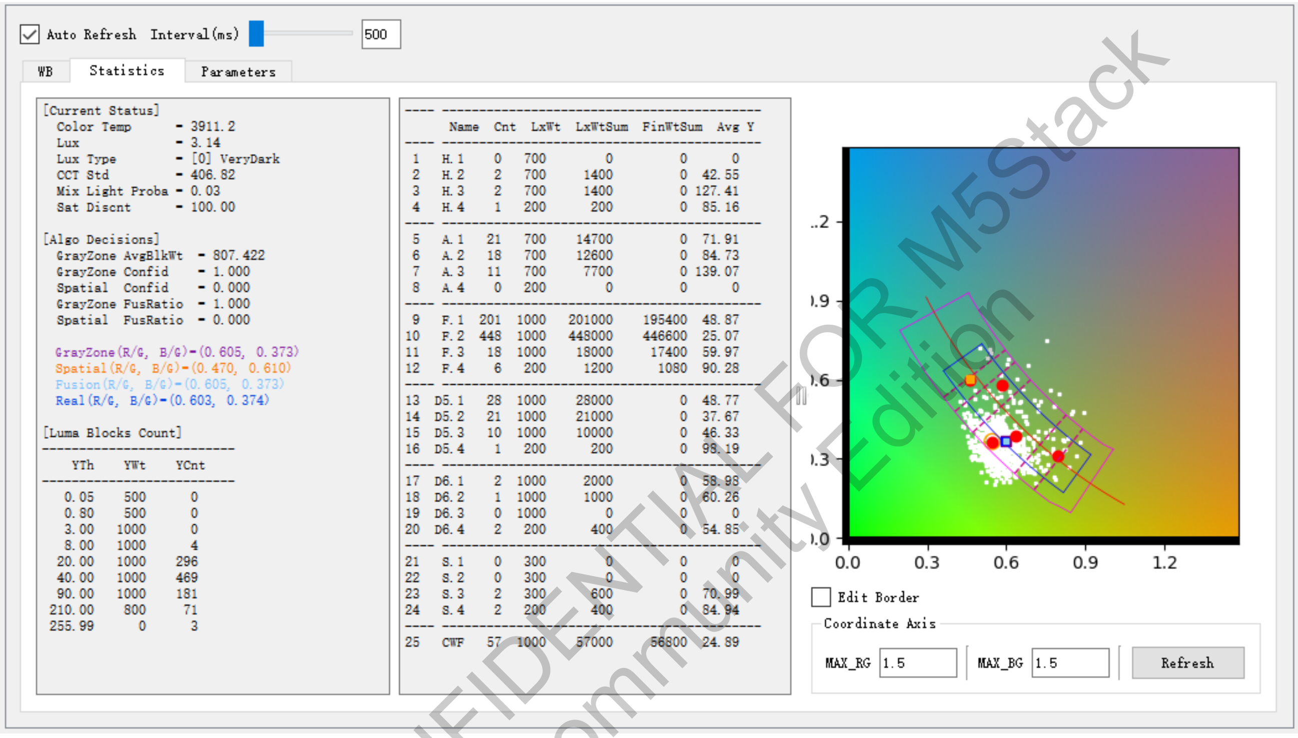
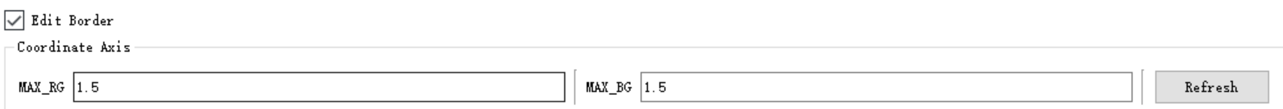


Figure 3-63 AWB Statistical Information

Auto Refresh Interval: A switch for the statistics information which can be turned on in auto white balance mode to automatically refresh statistics at set intervals.

Figure 3-64 Statistical Information Refresh

Adjusting Gray Zone



Edit Border: Allows online adjustment of the gray zone by dragging gray block points or selecting multiple blocks for batch dragging and dropping, as the figure below shows. Note: During drag-and-drop adjustments, ensure that auto-refresh is turned off.

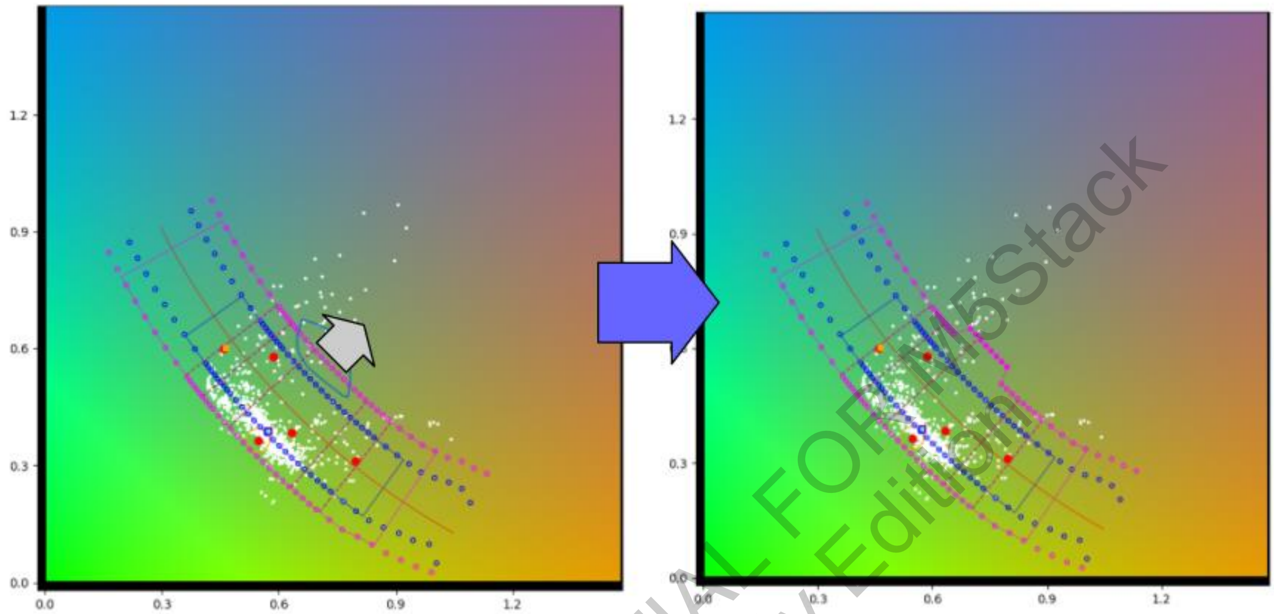


Figure 3-65 Adjusting Gray Zone

- MAX_RG is the max. range of the horizontal axis of the image.
- MAX_BG is the max. range of the vertical axis of the image.

General Information

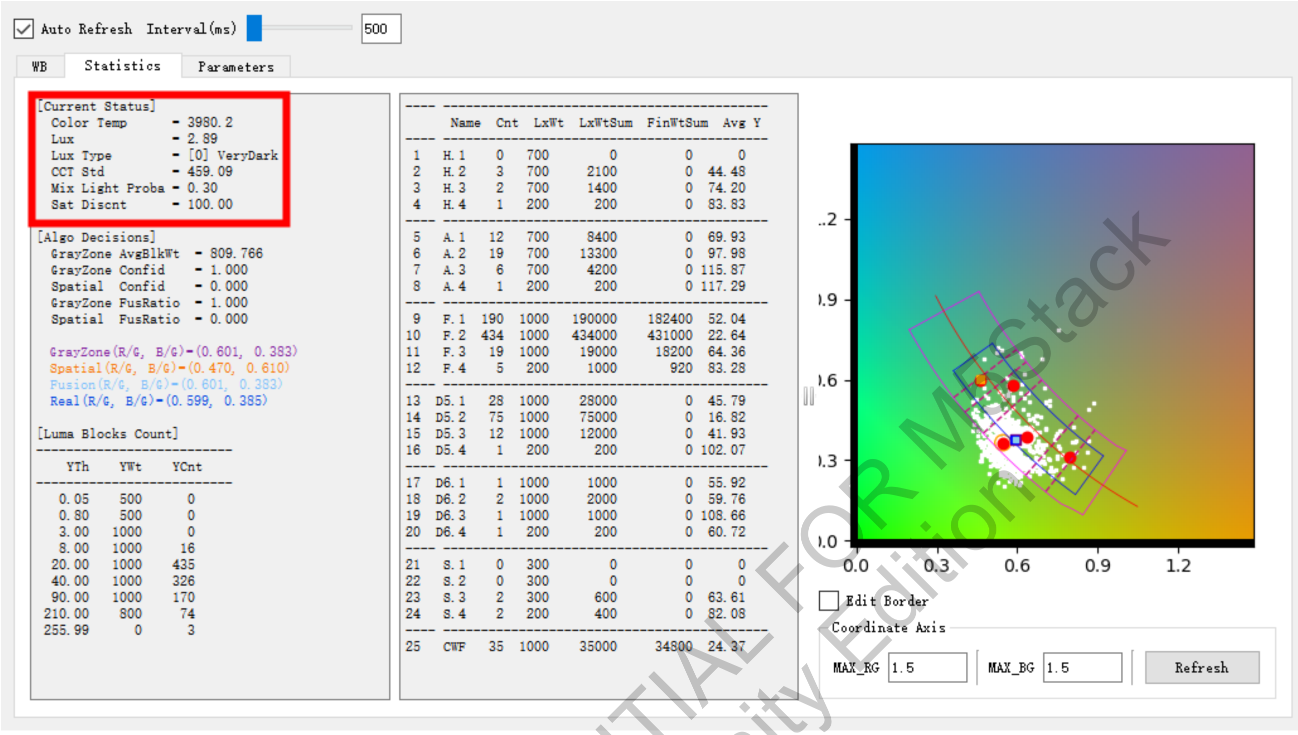


Figure 3-66 General Information

- Color Temp: Current color temperature.
- Lux: Current illuminance.
- Lux Type: Current brightness level.
- CCT Std: Dispersion of the white point; higher values indicate a higher probability of multiple color temperatures.
- Mix Light Proba: Multi-color temperature probability; higher values indicate a higher probability of multiple color temperatures.
- Sat Discnt: Saturation discount; higher values mean less discount.

Algorithm Status

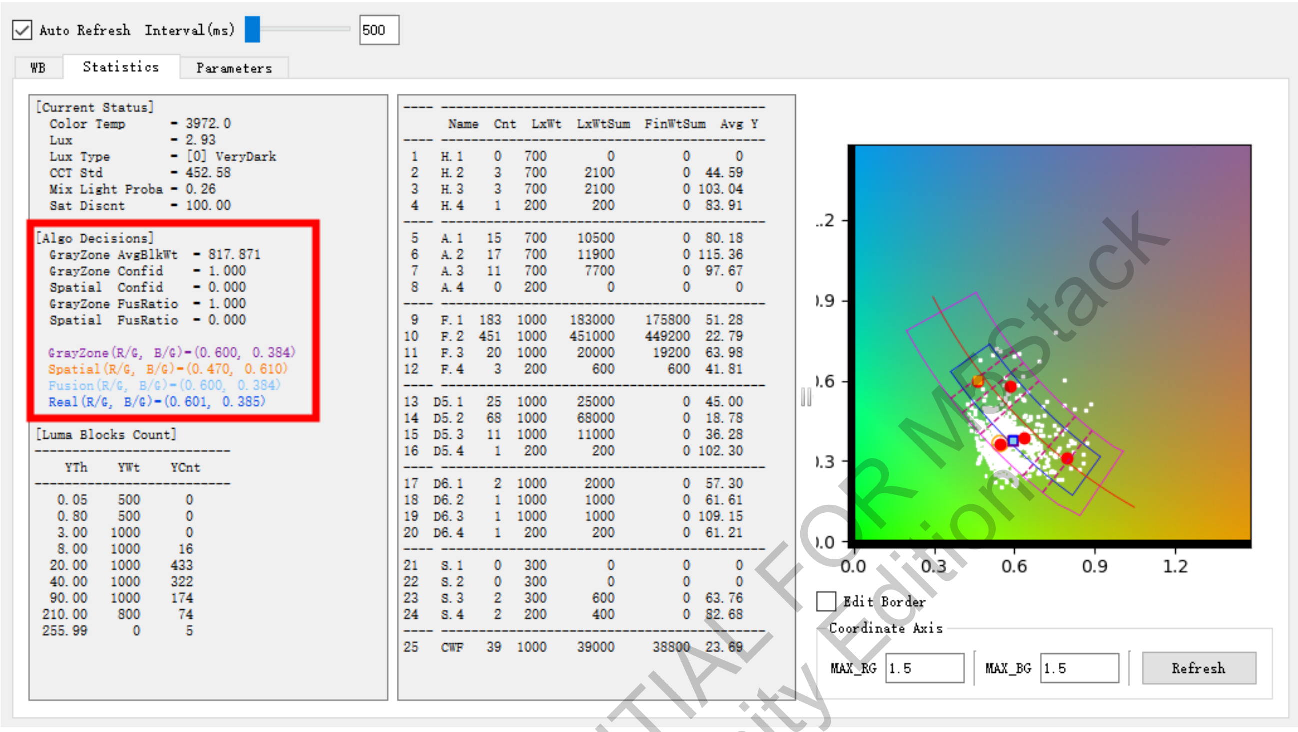


Figure 3-67 Algorithm Status

- GrayZone AvgBlkWt: Average illuminance weight for each statistical window.
- GrayZone Confid: Confidence in the advanced gray world.
- Spatial Confid: Anchoring confidence.
- GrayZone FusRatio: Fusion weight for the decision point in the advanced gray world.
- Spatial FusRatio: Fusion weight for the anchoring decision point.
- GrayZone (R/G, B/G): Decision point in the advanced gray world.
- Spatial (R/G, B/G): Anchoring decision point.
- Fusion (R/G, B/G): Post-fusion decision point.
- Real (R/G, B/G): AWB result decision point.

The position of the four decision points above on the Planckian Curve is shown in the figure below.

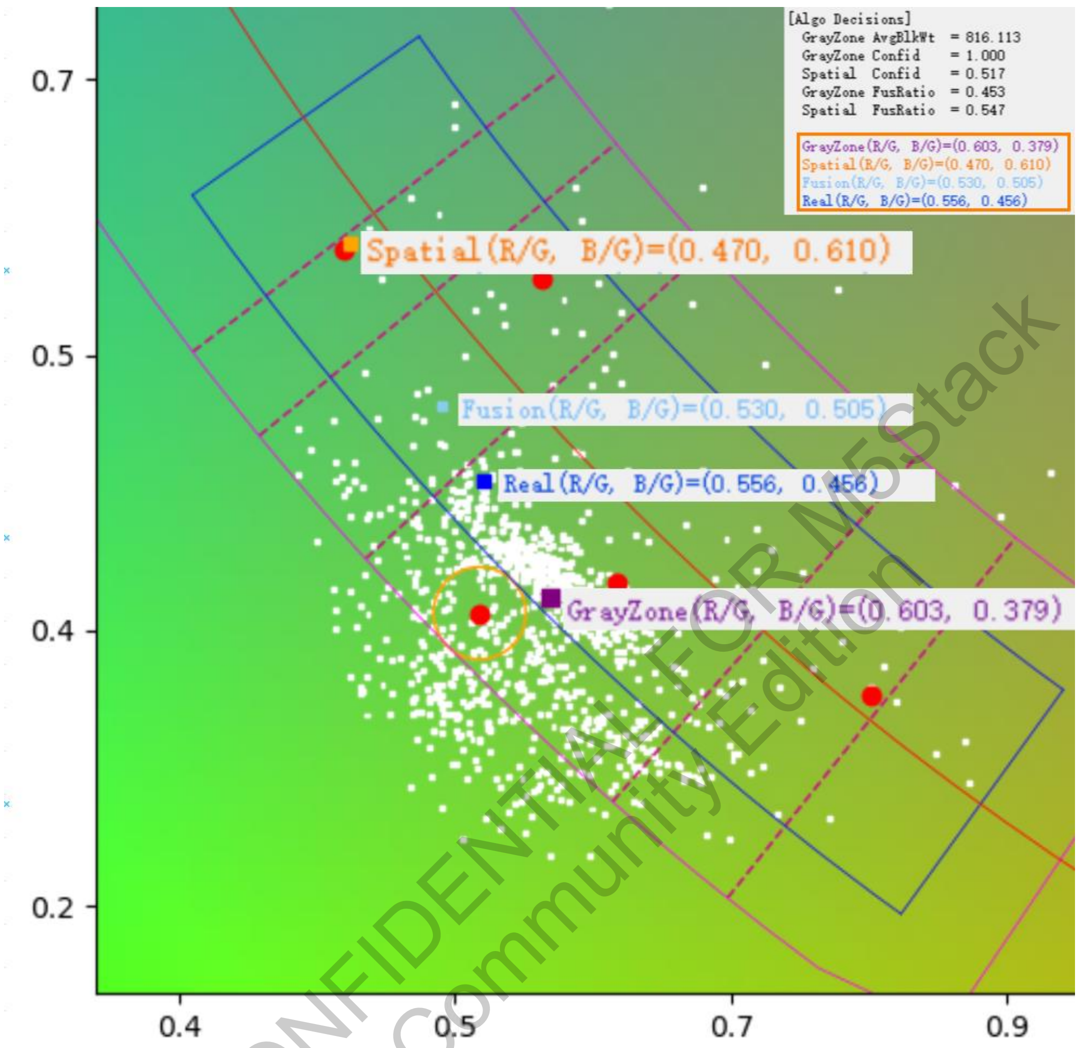


Figure 3-68 Decision Point

Light and Dark Block Information

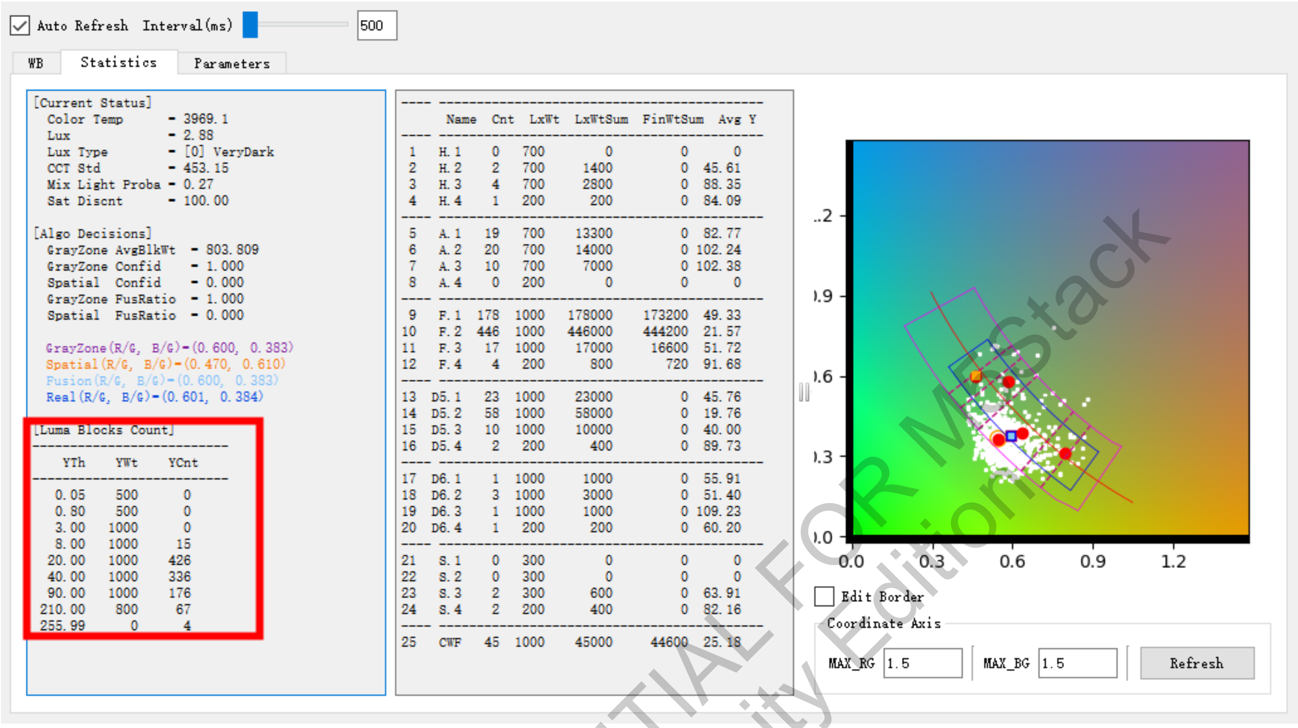


Figure 3-69 Light and Dark Statistical Block Information

For more information, refer to the Luma Weight (Brightness and Darkness Preference Strategy) in the AWB strategy part.

Advanced Gray World Algorithm Information

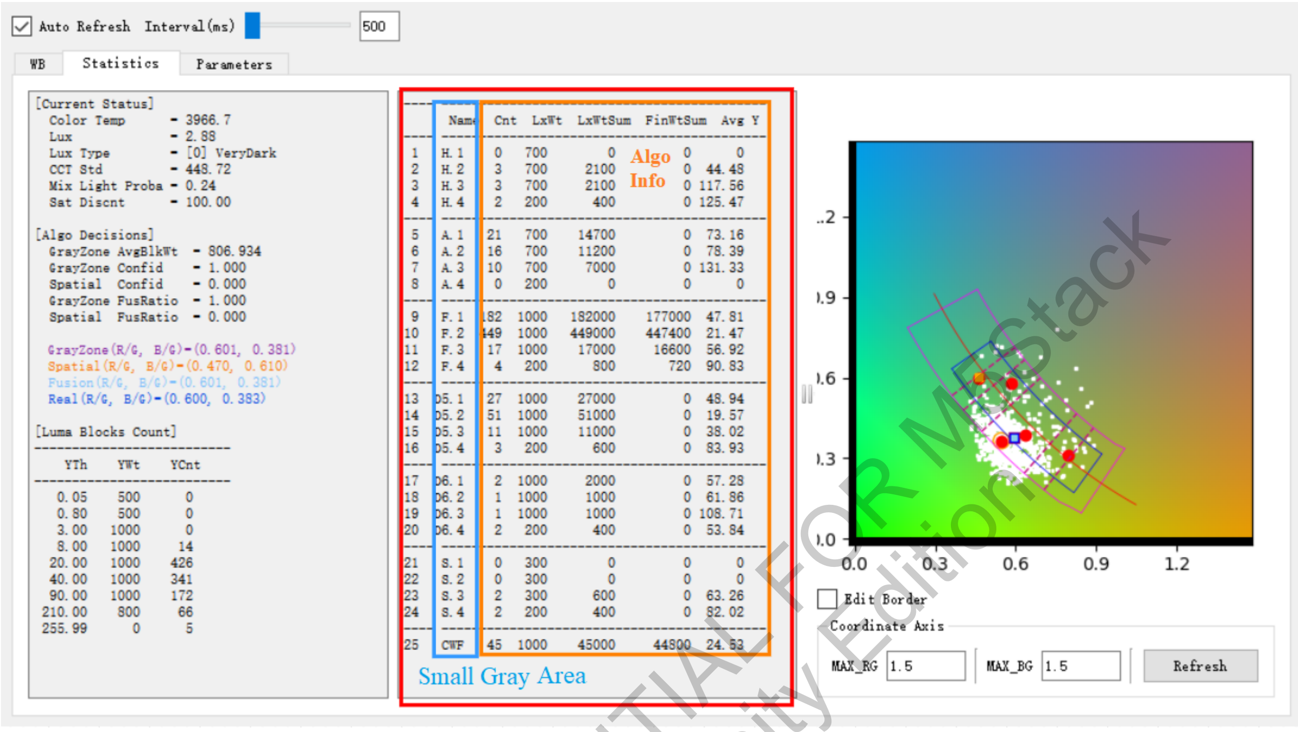


Figure 3-70 Advanced Gray World Algorithm Information

This page provides algorithm information for various small gray areas under specific Lux conditions:

- Cnt: Number of white points (statistical blocks) that fall into that small gray area.
- LxWt: Weight of that small gray area, ranging from 0 to 1000.
- LxWtSum: Weighted sum of all white points (statistical blocks) in that small gray area, calculated as LxWt (weight) × Cnt (number of white points).
- FinWtSum: Final weight used in calculations for that small gray area, calculated as LxWtSum (weighted sum) × Brightness/Darkness Preference Weight × Dominance Preference Weight × Multi-Temperature Preference Weight.
- Avg Y: Average luminance (Luma) of all white points (statistical blocks) in that small gray area, which can serve as a basis for Brightness and Darkness Preference Strategy (LumaWeight).

Gray World Block Statistics Information

In the preview interface, you can select specific blocks to view detailed detection points for assistance in debugging. To deselect a block, double-click the right mouse button.

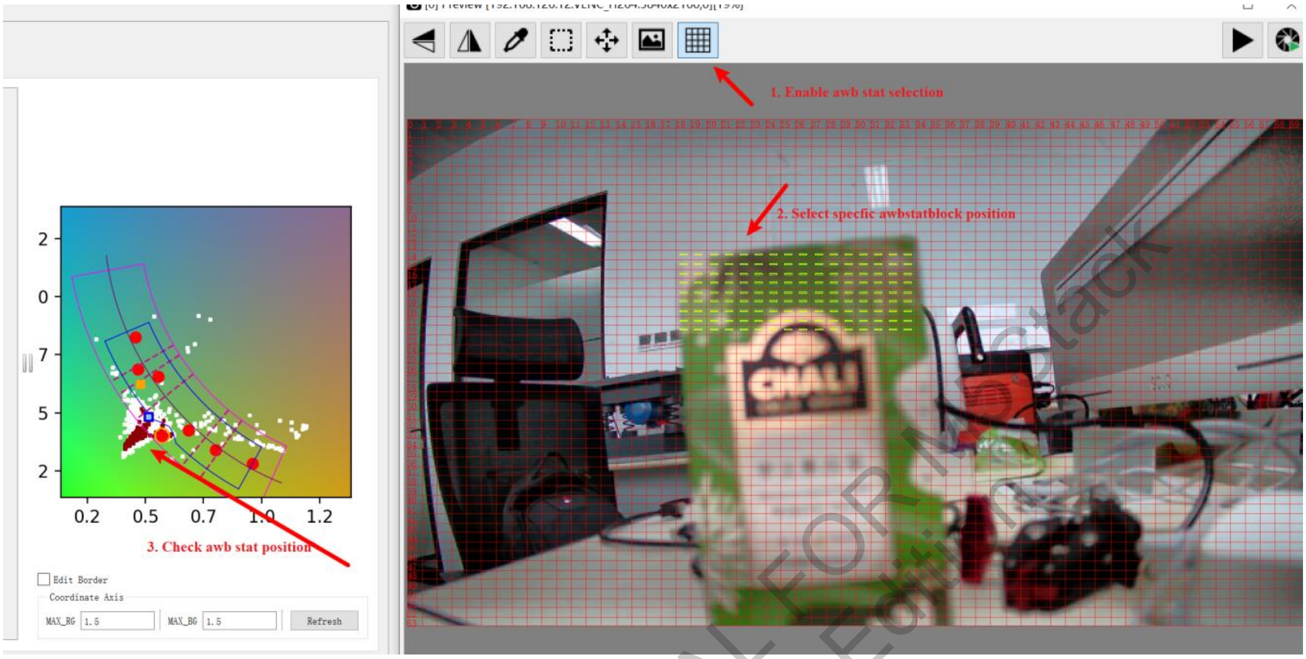


Figure 3-71 ROI Area Detection Points Statistics Information

3.3.5 Auto mode

Parameter Description

- Working Mode
  - Description: Switches between auto/manual mode
  - Parameter
    - Manual: MWB mode. WB Gain can be adjusted.
    - Auto: AWB mode.

3.4 AwbStat

3.4.1 Introduction

- AwbStat is primarily used to configure the information for the AWB statistical range. It is generally recommended not to adjust this unless necessary.
- It supports configurable total areas and count points for the AWB statistical grid and
- additionally allows for up to four ROIs, which can be used for near-gray pixel totals/counts and sums/counts based on Luma classification.

3.4.2 Interface

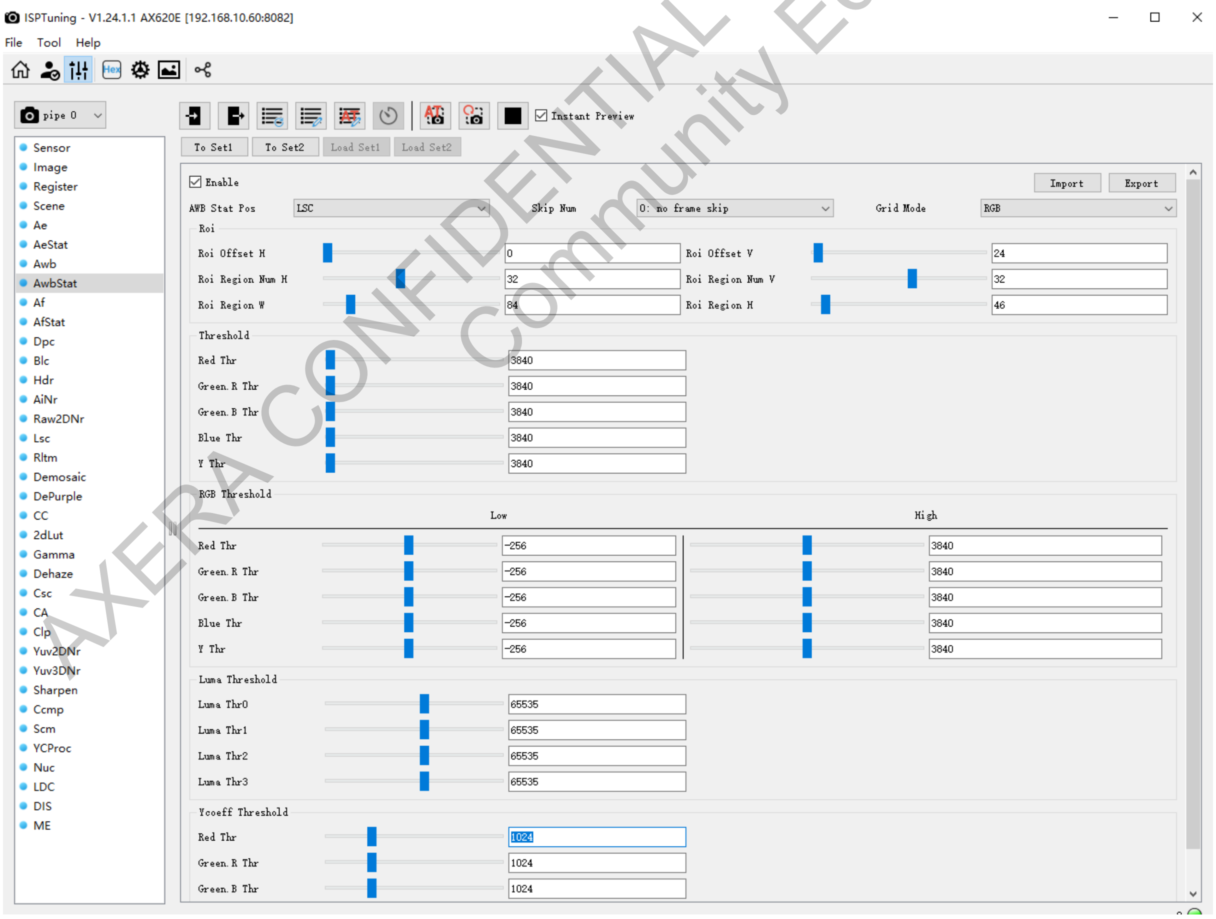


Figure 3-72 ROI Area Detection Points Statistics Information

3.4.3 Parameter

AwbStat		
Parameter	Description	Range
Enable	1: Enables AWB statistical module 0: Disables AWB statistical module	[0, 1]
AWB Stat Pos	AWB statistical position 0: After LSC 1: After RAW2DNR 3: After DPC long frame 4: After DPC short frame	[0, 4]
Skip Num	0: Do not skip frames 1: Skip 1/2 frames in 3a mode 2: Skip 2/3 frames in 3a mode	[0, 2]
Grid Mode	Grid mode 0: RGB, 1: RGGB, 2: RGGBxLuma4ch 3: RGGBxLuma2ch	[0, 3]
Roi offset H	The horizontal coordinate of the starting point for the Grid ROI for AWB block grid statistics.	[0, 2687]
Roi offset V	The vertical coordinate of the starting point for the Grid ROI for AWB block grid statistics.	[0, 1519]
Roi Region Num H	Number of horizontal grids for AWB statistics	[1, 72]
Roi Region Num V	Number of vertical grids for AWB statistics	[1, 54]
Roi Region W	The width of a single grid in the horizontal direction for AWB block grid statistics.	[16, 512]
Roi Region H	The height of a single grid in the vertical direction for AWB block grid statistics.	[16, 512]
Threshold		
Red Thr	The statistical threshold used for grid-based saturation and non-saturation value statistics in the R/Gr/Gb/B/Y channel for AWB.	[0, 1048575]
Green. R Thr		[0, 1048575]
Green. B Thr		[0, 1048575]

Blur Thr		[0, 1048575]
Y Thr		[0, 1048575]
RGB Threshold		
Red Thr	The R/Gr/Gb/B/Y channels' threshold settings for non-saturated pixel statistics. Pixels that fall within the range [Low, High] are considered as valid pixels.	[-524288, 524287]
Green. R Thr		[-524288, 524287]
Green. B Thr		[-524288, 524287]
Blur Thr		[-524288, 524287]
Y Thr		[-524288, 524287]
Luma Threshold		
Luma Thr0	For the R, Gr, Gb, B channels, each is divided into four brightness intervals, with pixels above these values considered as valid pixels for statistics.	[-524288, 524287]
Luma Thr1		[-524288, 524287]
Luma Thr2		[-524288, 524287]
Luma Thr3		[-524288, 524287]
Ycoeff Threshold		
Red Thr	R/Gr/Gb/B Channel Calibration Coefficient	[0, 4095]
Green. R Thr		[0, 4095]
Green. B Thr		[0, 4095]
Blur Thr		[0, 4095]

3.4.4 Debugging Recommendation

Generally, it is not necessary to adjust these parameters; it is recommended to use the default configuration.

3.5 Dpc

3.5.1 Introduction

DPC (Defected Pixel Correction) is a module used for correcting bad pixels caused by sensor quality, such as static bad pixels, damaged spots, and PDAF. Currently, it can remove up to two consecutive bad pixels.

- Supports static/dynamic single bad pixel correction, static/dynamic double bad pixel correction, and static 2×2 bad pixel cluster correction.
- Supports PDAF point extraction (PDAF Sensor).

➢ Supports IR point extraction, completes original IR points, and restores the Bayer pattern (RGB-IR Sensor).

3.5.2 Interface

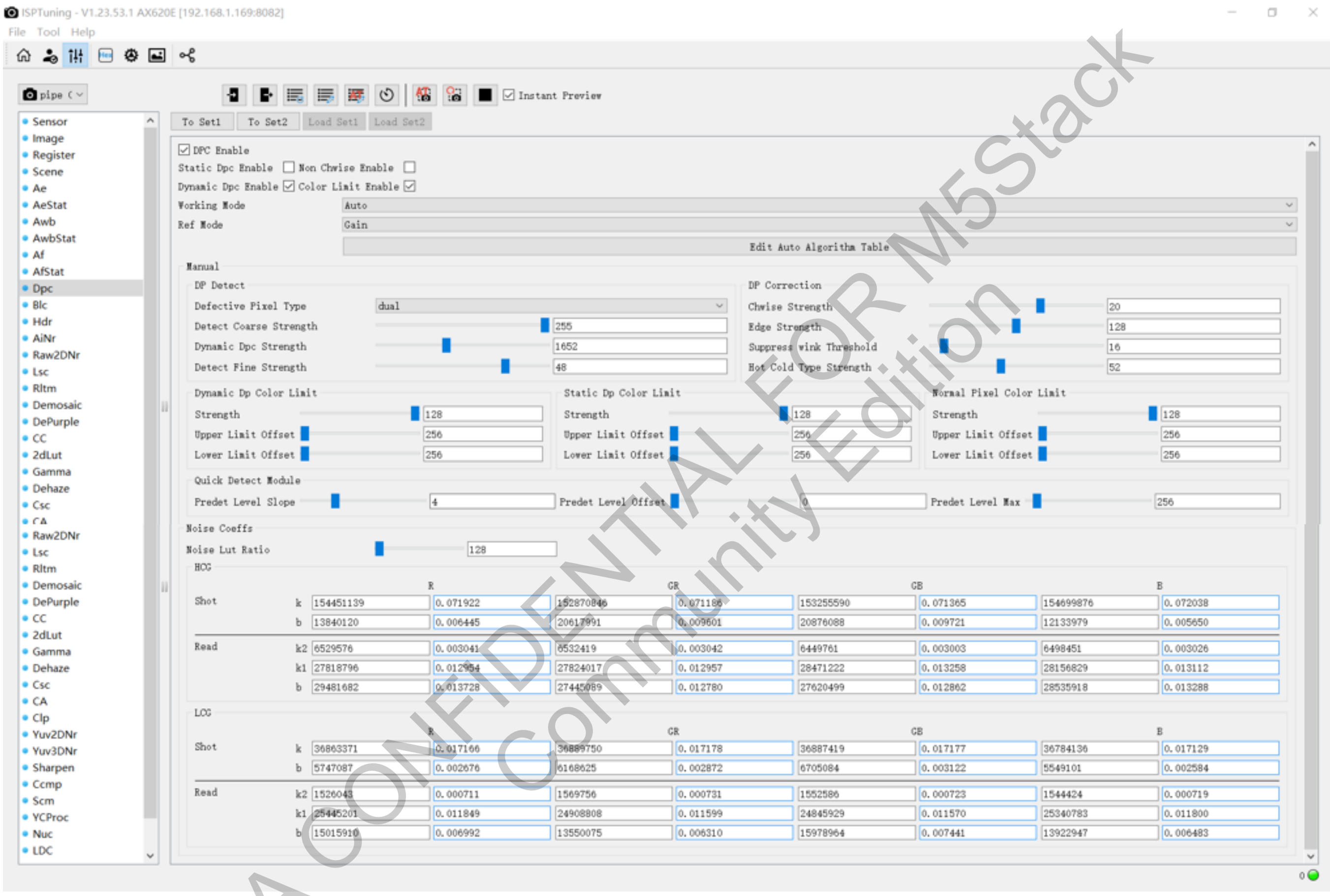


Figure 3-73 DPC Interface

3.5.3 Parameter

Parameter	Description	Range
DPC Enable	DPC enable switch.	0 1
Static Dpc Enable	Static bad pixel detection switch	0 1
Non Chwise Enable	When enabled, used for algorithmic selection to judge gradient information	0 1
Dynamic Dpc Enable	Toggle for enabling dynamic bad pixel detection	0 1

Color Limit Enable		Adjusts the color limits based on WB gain and surrounding pixel values to prevent over-saturation		/
Working Mode		Manual/Auto		/
Ref Mode		Gain/Lux		/
Edit Auto Algorithm Table		Allows editing of the automatic parameter configuration table		/
DP detect	Defective Pixel Type	Single	(Single defective pixel detection)	/
		Dual	(Multiple defective pixels detection)	/
	Detect Coarse Strength	Controls the intensity of the detection standard		0~255
	Dynamic Dpc Strength	Strength of dynamic bad pixel removal		0~4095
	Detect Fine Strength	Strength of dynamic bad pixel removal. The greater the Detect Fine Strength, the more bad pixels detected		0~63
Dp Correction	Chwise Strength	The lower the value, the stronger the bad pixel removal, used in scenes with many static 2x2 clusters		0~31
	Edge Strength	Higher values improve handling of edge-position bad pixels		0~255
	Suppress wink Threshold	Threshold for suppressing bad pixel flickering		0~255
	Hot Cold Type Strength	Strength for suppressing bright and dark bad pixels		0~128
Dynamic DP Color Limit	Strength	Strength for dynamic bad pixel limitation		0~128
	Upper Limit Offset	Upper limit compensation for dynamic bad pixel limitation		0~65535
	Lower Limit Offset	Lower limit compensation for dynamic bad pixel limitation		0~65535
Static Dp Color Limit	Strength	Strength for static bad pixel limitation		0~128
	Upper Limit Offset	Upper limit compensation for static bad pixel limitation		0~65535
	Lower Limit Offset	Lower limit compensation for static bad pixel limitation		0~65535
Normal Pixel Color Limit	Strength	Strength for reducing bad pixels by pixel mean value		0~128
	Upper Limit Offset	Upper limit for reducing bad pixels by pixel mean value		0~65535

	Lower Limit Offset	Lower limit for reducing bad pixels by pixel mean value	0~65535
Quick Detect Module	Predet Level Slope	Slope for pre-detecting bad pixels	0~15
	Predet Level Offset	Offset for pre-detecting bad pixels	0~4095
	Predet Level Max	Maximum value for pre-detecting bad pixels	0~4095
Noise Lut Ratio		Calibration ratio for adjusting noise, to minimize noise impact on DPC	0~10239
Noise Coeffs		HCG Shot, LCG Shot, HCG Read, and LCG Read are obtained through calibration; manual changes not advised	DPC Calibration

Debugging suggestion:

Due to the impact of DPC on detail clarity, it is recommended not to enable it at low ISO levels (0-400). For ISO levels between 400-1600, enable DPC at the weakest setting. For ISO levels from 1600 to the maximum, activate moderate to strong intensity corrections for bad pixels as needed.

3.5.4 Debugging Method

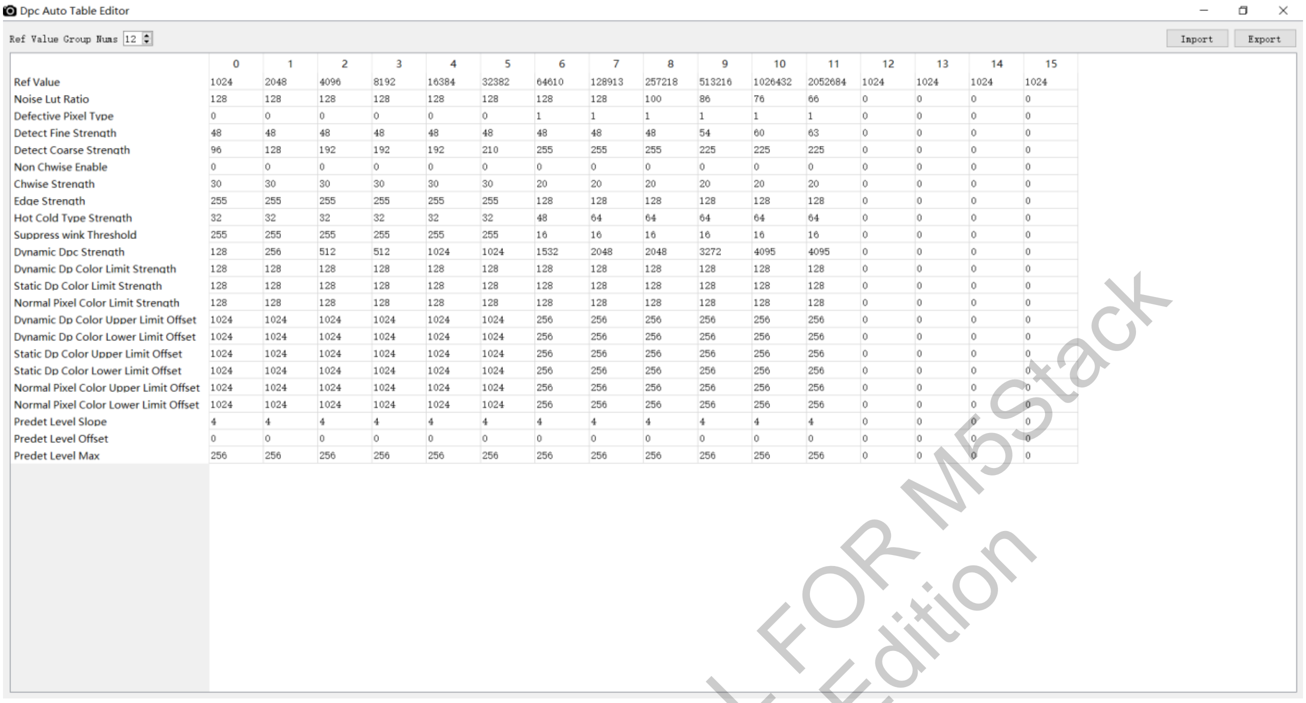
1) Enable Dynamic DPC: Start by turning on Dynamic Dpc Enable and set the dynamic correction strength to the maximum (Dynamic Dpc Strength set to max).
2) Observe the Nature of Defective Pixels: If single defective pixels are more frequent, set Defective Pixel Type to 0. If double defective pixels are predominant, configure Defective Pixel Type to 1.
3) Adjust Pre-detection Settings: Modify Predet Level Slope, Predet Level Offset, and Predet Level Max to pre-detect bad pixels effectively.
4) Check for Missed Defective Pixels: If some bad pixels are missed, increase Detect Coarse Strength and Detect Fine Strength to find the appropriate threshold.
5) Reduce Dynamic DPC Strength: Lower the bad pixel removal strength and compare with the original image (without DPC) until the loss in clarity becomes acceptable.
6) Observe Edge-positioned Bad Pixels: If the removal of edge-positioned bad pixels is inadequate,

increase Edge Strength to enhance correction effects at edges, although this may also result in a loss of resolution.

3.5.5 Auto mode

Parameter Description

- Working Mode
  - Description: Switches between auto/manual mode
  - Parameter
    - Manual: In manual mode, parameters can be freely adjusted.
    - Auto: In automatic mode, parameters are adjusted based on gain/luminance as reference values.
- Ref Mode
  - Choice of reference value type for the automatic strategy, which affects the meaning of Ref Val in the Auto Algorithm Table.
  - Parameter
    - Lux: In this mode, Ref Val in the Auto Algorithm Table is actually the Lux value. This parameter changes with the illuminance.
    - Gain: In this mode, Ref Val in the Auto Algorithm Table is actually the gain. This parameter changes with the gain.
- Ref Val
  - Displays the current numerical value of Ref Val.



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ref Value	1024	2048	4096	8192	16384	32382	64610	128913	257218	513216	1026432	2052684	1024	1024	1024	1024
Noise Lut Ratio	128	128	128	128	128	128	128	128	100	86	76	66	0	0	0	0
Defective Pixel Type	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0
Detect Fine Strength	48	48	48	48	48	48	48	48	48	54	60	63	0	0	0	0
Detect Coarse Strength	96	128	192	192	192	210	255	255	255	225	225	225	0	0	0	0
Non Chwise Enable	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chwise Strength	30	30	30	30	30	30	20	20	20	20	20	20	0	0	0	0
Edge Strength	255	255	255	255	255	255	128	128	128	128	128	128	0	0	0	0
Hot Cold Type Strength	32	32	32	32	32	32	48	64	64	64	64	64	0	0	0	0
Suppress wink Threshold	255	255	255	255	255	255	16	16	16	16	16	16	0	0	0	0
Dynamic Dpc Strength	128	256	512	512	1024	1024	1532	2048	2048	3272	4095	4095	0	0	0	0
Dynamic Dp Color Limit Strength	128	128	128	128	128	128	128	128	128	128	128	128	0	0	0	0
Static Dp Color Limit Strength	128	128	128	128	128	128	128	128	128	128	128	128	0	0	0	0
Normal Pixel Color Limit Strength	128	128	128	128	128	128	128	128	128	128	128	128	0	0	0	0
Dynamic Dp Color Upper Limit Offset	1024	1024	1024	1024	1024	1024	256	256	256	256	256	256	0	0	0	0
Dynamic Dp Color Lower Limit Offset	1024	1024	1024	1024	1024	1024	256	256	256	256	256	256	0	0	0	0
Static Dp Color Upper Limit Offset	1024	1024	1024	1024	1024	1024	256	256	256	256	256	256	0	0	0	0
Static Dp Color Lower Limit Offset	1024	1024	1024	1024	1024	1024	256	256	256	256	256	256	0	0	0	0
Normal Pixel Color Upper Limit Offset	1024	1024	1024	1024	1024	1024	256	256	256	256	256	256	0	0	0	0
Normal Pixel Color Lower Limit Offset	1024	1024	1024	1024	1024	1024	256	256	256	256	256	256	0	0	0	0
Predet Level Slope	4	4	4	4	4	4	4	4	4	4	4	4	0	0	0	0
Predet Level Offset	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Predet Level Max	256	256	256	256	256	256	256	256	256	256	256	256	0	0	0	0

Figure 3-74 Dpc Auto Table

3.6 Blc

3.6.1 Introduction

BLC (Black Level Correction) is a module that compensates for the black level in the raw domain.

- Supports fixed black level correction.
- Supports black level correction based on a calibrated mesh table.
- Supports dynamic statistics and correction of the black level.
- Supports fixed mode noise correction for the entire image.
- Supports effective area cropping.
- Supports data mapping at a certain magnification.

3.6.2 Interface

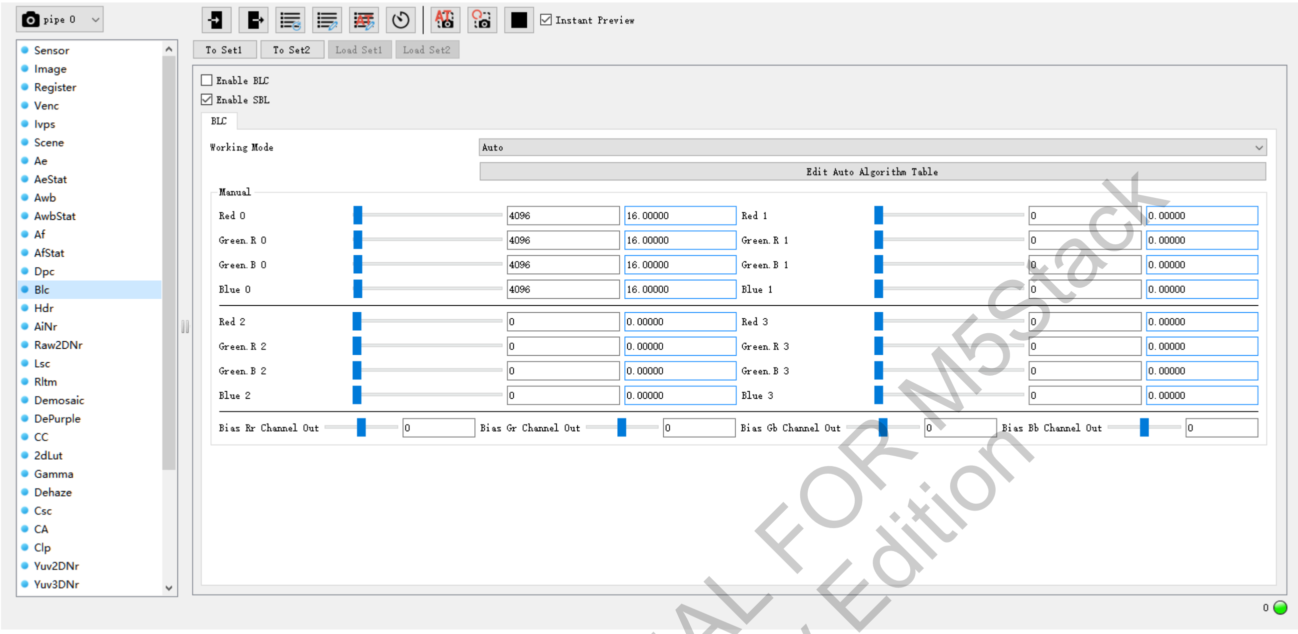


Figure 3-75 BLC Interface

3.6.3 Parameter

Parameter	Description	Range
Enable BLC	Toggle switch for BLC, recommended to be turned on	0 1
Enable SBL	Toggle for fixed black level correction FPN module, recommended to be turned on	0 1
Working Mode	Manual/Auto	Manual/Auto
Edit Auto Algorithm Table	Allows editing of the automatic parameter configuration table	0~23
Red x	Subtraction value for dark current in the R channel	0~4096
Green.R x	Subtraction value for dark current in the Gr channel	0~4096
Green.B x	Subtraction value for dark current in the GB channel	0~4096
Blue x	Subtraction value for dark current in the B channel	0~4096
Bias x channel out	A compensation subtraction value for the dark current in four channels. This allows for more precise control over the BLC calibration values. A unit value of 1 in the compensation subtraction is equivalent to one-fourth of the dark current subtraction value.	[-16384, 16383]

3.6.4 Auto mode

Parameter Description

- Working Mode
  - Description: Switches between auto/manual mode
  - Parameter
    - Manual: In manual mode, parameters can be freely adjusted.
    - Auto: In automatic mode, parameters are adjusted based on gain/luminance as reference values.
- Ref Mode
  - Choice of reference value type for the automatic strategy, which affects the meaning of Ref Val in the Auto Algorithm Table.
  - Parameter
    - Lux: In this mode, Ref Val in the Auto Algorithm Table is actually the Lux value. This parameter changes with the illuminance.
    - Gain: In this mode, Ref Val in the Auto Algorithm Table is actually the gain. This parameter changes with the gain.

! Notes:

In HCGmode, BLC Gain is TotalGain/HCG2LCGRatio.

- Ref Val
  - Displays the current numerical value of Ref Val.

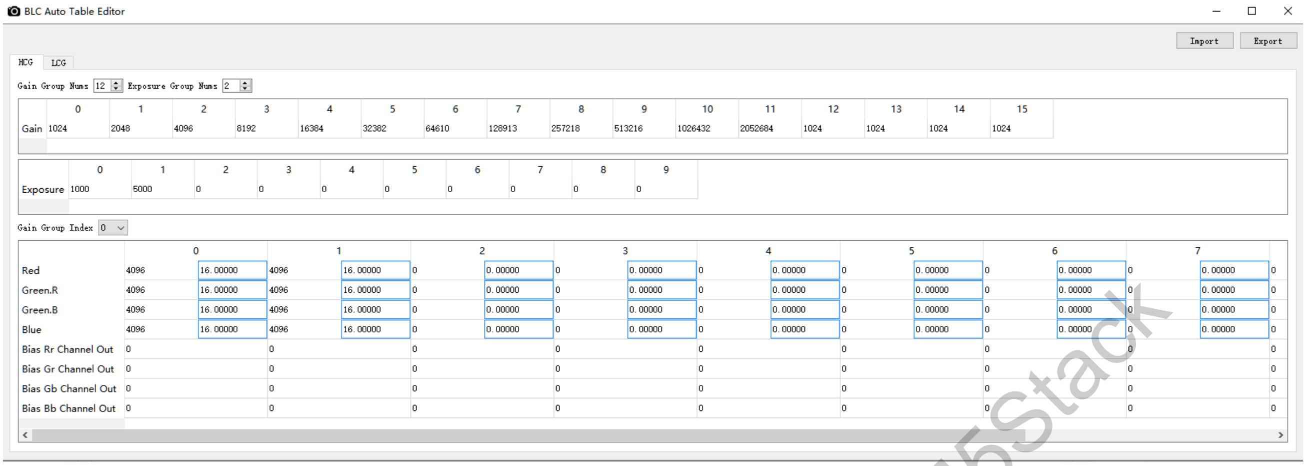


Figure 3-76 BLC Auto Table

3.7 Hdr

3.7.1 Introduction

HDR (High Dynamic Range) involves the synthesis of one HDR image from multiple SDR (Standard Dynamic Range) images in the raw domain. It supports multiple HDR formats including HDR-2DOL and HDR-3DOL.

Main components of the HDR system:

- Fusion: This module is responsible for blending up to three SDR images to produce a single HDR image.
- Motion Detection: This module compares pairs of input SDR images to detect any motion between them. It generates a Motion Mask, which is used during the Fusion process to adjust the weights of the images based on the detected motion.
- Debug: The Debug module can output the Motion Mask to assist with parameter tuning.

3.7.2 Interface

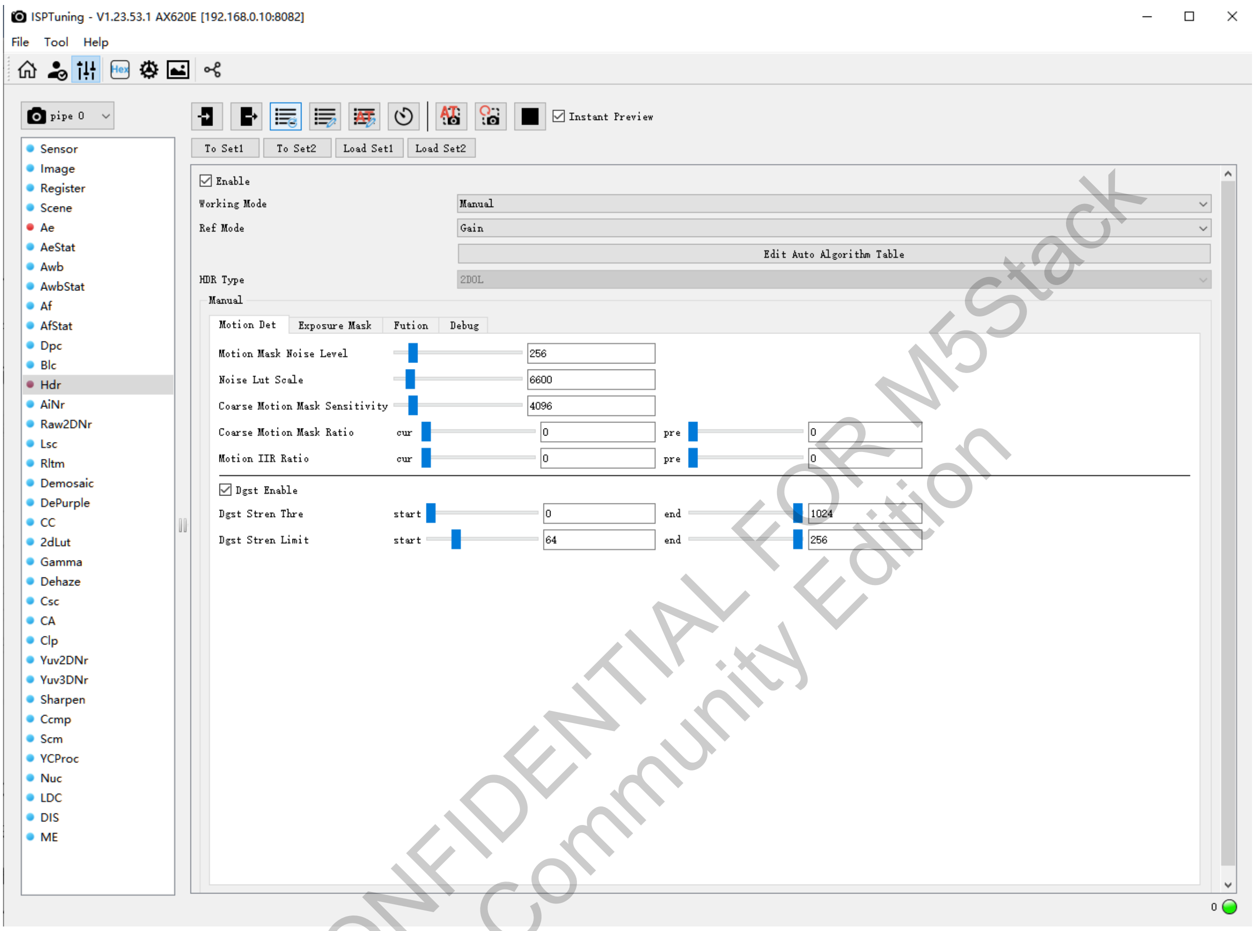


Figure 3-77 HDR Parameter Configuration

3.7.3 Parameter

- Enable: Toggle for enabling HDR functionality (only effective in HDR-2DOL, HDR-3DOL modes; no effect in SDR mode). HDR mode is enabled by default.
- Working Mode: Switch between Manual and Auto modes. Manual mode uses a set of currently configured parameters, suitable for manual debugging in specific scenarios. In Auto mode, parameters are automatically adjusted based on the Lux/Gain of the current environment by using linear interpolation from the auto parameter table.
- Ref Mode: Sets the reference for the automatic strategy in Auto mode, either based on Lux or Gain.

- Edit Auto Algorithm Table: Configure parameters for Auto mode.

Motion Detection and Deghosting Modules

- Motion Mask Noise Level: Parameter measuring the noise level of the current scene; pixel differences below this value are considered noise, and only differences above this value are detected as motion. The higher the value, the harder it is to detect motion; the lower the value, the easier it is to detect motion. Value range: [0, 2048] Default: 256
- Noise Lut Scale: The higher the value, the less sensitive it is to motion; the lower the value, the more sensitive. Value range: [0, 65535] Default: 4096 Both Motion Mask Noise Level and Noise Lut Scale together determine the outcome of motion detection.
- Coarse Motion Mask Sensitivity: Sensitivity for detecting coarse motion areas. A higher value increases the detection rate of coarse motion areas, while a lower value decreases it. Value range: [0, 32768] Default: 4096
- Coarse Motion Mask Ratio: The proportion of the motion area that appears in coarse granularity. Higher values result in motion areas being displayed more coarsely; lower values result in finer granularity. This parameter is recommended to be set to 0 and not enabled.
  - Coarse Motion Mask Ratio[0]: Effective when the fine granularity mask strength ≥ coarse granularity mask strength; represents the weight of coarse granularity. Value range: [0, 256]
  - Coarse Motion Mask Ratio[1]: Effective when the fine granularity mask strength < coarse granularity mask strength; represents the weight of coarse granularity. Value range: [0, 256]
- Motion IIR Ratio: Controls the ratio for IIR filtering of motion areas. Higher values result in stronger filtering by the IIR filter; lower values result in weaker filtering. This parameter is recommended to be set to 0 and not enabled.
  - Motion IIR Ratio[0]: Effective when the motion mask strength of the current frame ≥ the motion mask strength of the previous frame; represents the coarse granularity weight. Value range: [0, 256]
  - Motion IIR Ratio[0]: Effective when the motion mask strength of the current frame < the motion mask strength of the previous frame; represents the coarse granularity weight. Value range: [0, 256]

- Dgst Enable: Toggle for enabling deghosting. This parameter is recommended to be enabled.
- Dgst Stren Thre: Controls the intensity of deghosting. The default value of {Dgst Stren Thre[0], Dgst Stren Thre[1]}= (0, 1024) is recommended.
- Dgst Stren Limit: Controls the upper and lower limits of deghosting strength. Dgst Stren Limit[0] controls the lower limit; value ange: [0, 255]. Dgst Stren Limit[1] controls the upper limit; value range: [0, 256]. Default value is (0, 256).

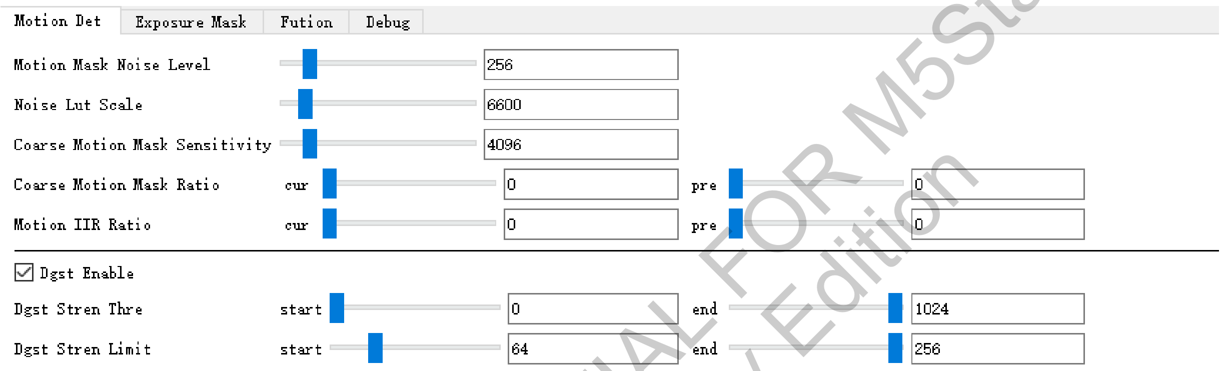


Figure 3-78 Motion Det Parameter Configuration

Exposure Mask Detection Submodule

> In this page, frame0 corresponds to the short frame input of HDR, while frame1 corresponds to the long frame input of HDR.

- Coarse Exposure Mask Ratio: The ratio of coarse-grained exposure areas. A larger value results in the final exposure area being displayed in coarse granularity, while a smaller value results in the final exposure area being displayed in fine granularity. This parameter is recommended to be set to 0 and not enabled.
  - Coarse Exposure Mask Ratio[0]: This coefficient is effective when the intensity of fine-grained exposure mask is greater than or equal to the intensity of coarse-grained exposure mask. Value range: [0, 256].
  - Coarse Exposure Mask Ratio[1]: This coefficient is effective when the intensity of fine-grained exposure mask is less than the intensity of coarse-grained exposure mask. Value range: [0, 256].

- Exp Mask Sensitivity: The sensitivity of coarse-grained exposure area intensity. A larger value leads to a higher detection rate of coarse-grained exposure areas, while a smaller value leads to a lower detection rate. Value range: [0, 32768]. 4096 by default.

☞ Exposure Area: Depends on the settings of exp weight gain & exp weight lut.

- Exp IIR Ratio: Control ratio of IIR filter for filtering overexposed areas. A larger value indicates stronger filtering by the IIR filter, while a smaller value indicates weaker filtering. This parameter is recommended to be set to 0 and not enabled.
  - Exp IIR Ratio[0]: This coefficient is effective when the exposure mask intensity of the current frame is greater than or equal to the exposure mask intensity of the previous frame. Value range: [0, 256].
  - Exp IIR Ratio[1]: This coefficient is effective when the exposure mask intensity of the current frame is less than the exposure mask intensity of the previous frame. Value range: [0, 256].
- Exp Y Ratio: Y value calculation for exp mask, with two algorithms: wb_gain value and dgain value. The Exp Y Ratio parameter represents the weight of the wb_gain algorithm when calculating Y value. A larger value indicates a greater weight of the wb_gain. Range: [0, 256]. 0 by default.
- Exp Weight Gain: Modulation parameter of exposure mask, adjusting the global exposure weight for short/long frames. A larger value indicates higher weight, while a smaller value indicates lower weight. This parameter is recommended to be set to (0, 256).
- Dgst Base Fid: Selection of the base frame for fusion; 0 is frame0, 1 is frame1. 1 by default.
- Exp Weight Lut: Generation parameter of exposure mask, generating local exposure weights for Long/Short/VShort based on different brightness levels. A larger value indicates higher weight, while a smaller value indicates lower weight. The horizontal axis represents luminance, and the vertical axis represents weight.
  - The x-axis represents pixel brightness (luma: 0-255), and the y-axis represents weight with a value range of [0, 32768].

  Control Points: Adjust the number of debug nodes for quick modification.

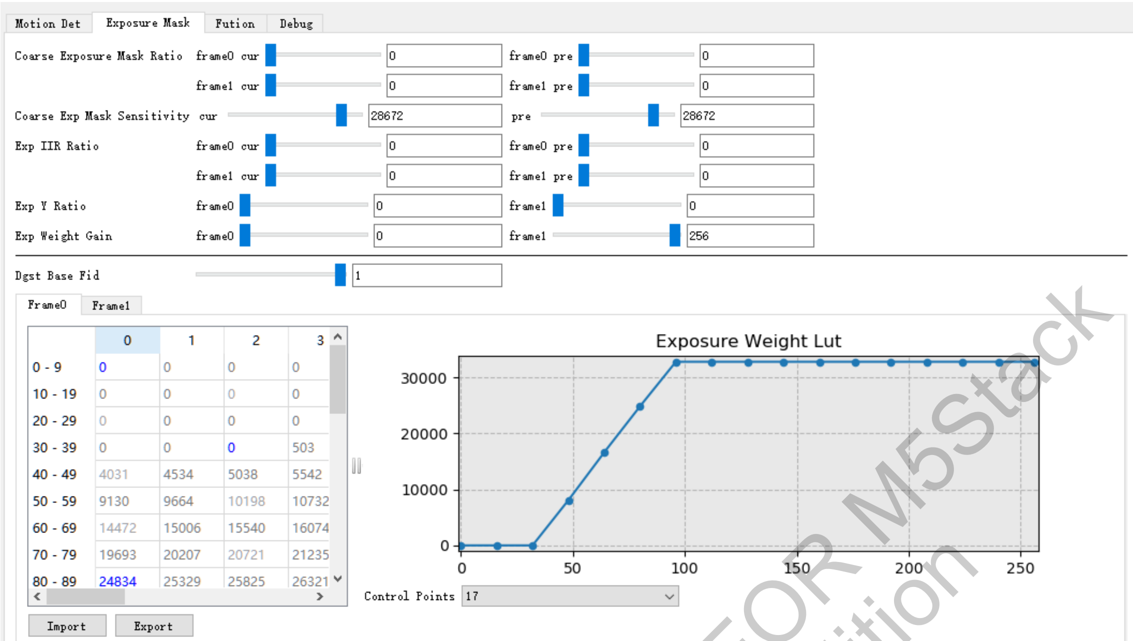


Figure 3-79 Exposure Mask Parameter Configuration

Fusion

> In this page, frame0 corresponds to the short frame input of HDR, while frame1 corresponds to the long frame input of HDR.

- Fus Prot Thrs: Protection threshold for fusing highlights. A smaller value indicates stricter fusion, while a larger value indicates looser fusion. Value range: [0, 262143]; Recommended value: (16000, 16192). During actual debugging, this value can be appropriately reduced to address issues with bright edge artifacts.
  - Parameter values are pixel brightness values of 14-bit images; typically, for pixel brightness values of 8-bit images, they need to be multiplied by 64 (i.e., 2^6) before inputting.
  - Fus Prot Thrs[0]: Pixels less than or equal to Fus Prot Thrs[0] are fully fused.
  - Fus Prot Thrs[1]: Pixels greater than or equal to Fus Prot Thrs[1] are not fused at all.
  - Pixels between Fus Prot Thrs[0] and Fus Prot Thrs[1] are fused proportionally.

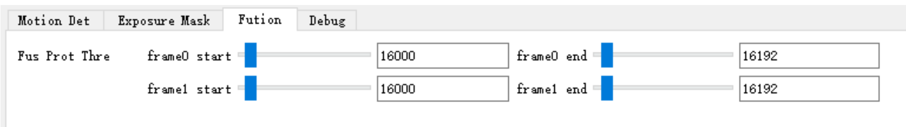


Figure 3-80 Fusion Parameter Configuration

Debug Submodule

- Debug Mode: Debug mode, selecting different modes will display corresponding HDR debug masks on the preview interface.
  - Mode0 - Off
  - Mode1 - Comprehensive Debug Image (includes all information from Weight Mask and Motion Mask, most commonly used)
  - Mode2 - Display Motion Mask
  - Mode3 - Display Exp Mask of the long frame
  - Mode4 - Display Exp Mask of the short frame

Figure 3-81 HDR Debug Mask1

☞ For DebugMaskMode1,

☞ Green Highlighted Area: Represents a motion area, with high weight in frame1 (long frame) and low weight in frame0 (short frame).

☞ Purple Highlighted Area: Represents a motion area, with high weight in frame0 (short frame) and low weight in frame1 (long frame).

3.7.4 Auto mode

Parameter Description

- Working Mode
  - Switching between auto/manual modes
  - Parameter
    - Manual: In manual mode, parameters can be freely adjusted.
    - Auto: In automatic mode, parameters based on gain/luminance Lux serve as reference value Ref Val to select appropriate parameters.
- Ref Mode
  - Selection of reference value type. This value affects the meaning of Ref Val in the Auto Algorithm Table.
  - Parameter
    - Ref Mode=0 represents using Lux: In this case, Ref Val in the Auto Algorithm Table actually represents Lux. The current parameter changes with illuminance.
    - Ref Mode=1 represents using Gain: In this case, Ref Val in the Auto Algorithm Table actually represents gain. T hus, the current parameter changes with gain.

☞ When Ref Mode uses Gain, the Gain here is Total Gain (current Again × current Dgain × current ISPGain × LCGHCGRatio).

- Ref Val
  - Displays the current numerical value of Ref Val. Gain/Lux × 1024.

3.8 AiNr

3.8.1 Introduction

AiNR Module: Utilizes model training results to perform noise reduction processing on images, mainly including temporal noise reduction and spatial noise reduction.

3.8.2 Interface

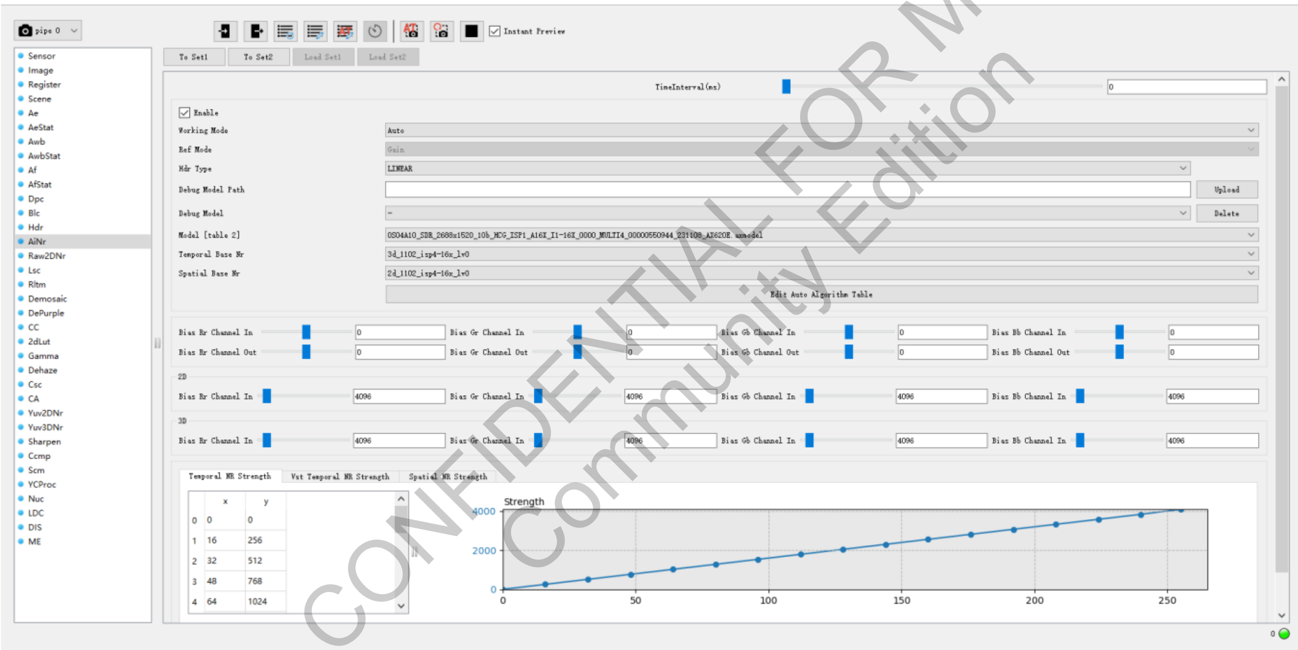


Figure 3-82 AiNR Parameter Configuration

3.8.3 Parameter

AiNR		
Parameter	Description	Range
Enable	AI denoising enable switch	0 1
Ref Mode	Selection of reference value type. This value determines the basis for Ref Val in the Auto Algorithm Table. When Ref Val is Lux, auto parameters change with	Lux/gain

	illuminance. When Ref Val is gain, auto parameters change with gain.	
Hdr Type	LINEAR for linear SDR mode, and HDR_2X for HDR mode	LINEAR/HDR_2X/ HDR_3X/HDR_4X
Debug Model Path	Local model loading path, click Upload to load locally stored model files	/
Debug Model	Local loaded model, click the drop-down box to switch between multiple models, click Delete to remove the selected model	/
Model[table 2]	Default version models configured in iq.h, click the drop-down box to see multiple models configured in iq.h	/
Temporal Base Nr	Base strength of temporal noise reduction in models. WBT models integrate various levels of temporal noise reduction, which can be freely selected from the drop-down box	/
Spatial Base Nr	Base strength of spatial noise reduction in models. WBT models integrate various levels of spatial noise reduction, which can be freely selected from the drop-down box	/
Edit Auto Algorithm Table	Automatic parameter configuration table	/
Bias Rr Channel In/Out	Modulation of BLC at the model end to improve BLC accuracy issues, affecting noise and color	-4096~4095
2D/3D Bias Rr/Gr/Gb/Bb Channel In	Affects the noise of input data to the ainr model, generally agreed to be the same as sensor's BL, not recommended for debugging.	0~65535
Temporal NR Strength	Temporal noise reduction strength table in the model, from left to right, representing static to dynamic areas	0~4096
Vst Temporal NR Strength	VST model spatial noise reduction strength table, from left to right, representing static to dynamic areas, recommended to use default values or fine-tune	0~4096
Spatial NR Strength	Spatial noise reduction strength table in the model, from left to right, representing static to dynamic areas, larger values indicate stronger noise reduction	0~4096

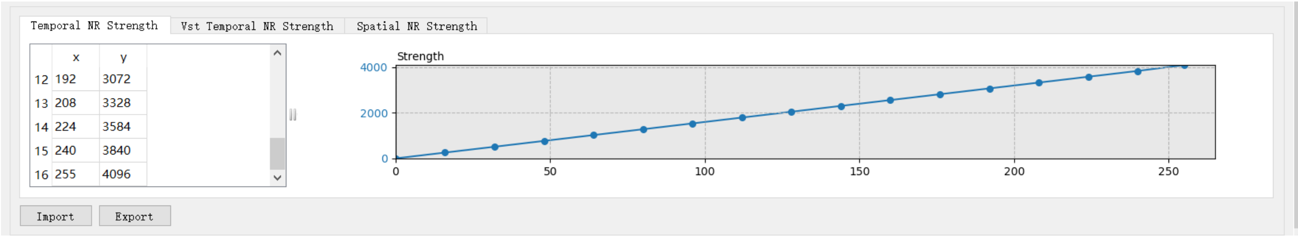


Figure 3-83 AiNr_Temporal_NR_Strength Parameter Configuration

☞ As shown in the above graph, the horizontal axis from left to right represents the static area to the motion area. The vertical axis represents temporal strength, where a larger value indicates weaker temporal strength. It is recommended to use the default curve. In most cases, it can accurately distinguish between motion and static areas. Under high gain, you can appropriately increase the values of the last few points to improve the degree of trailing.

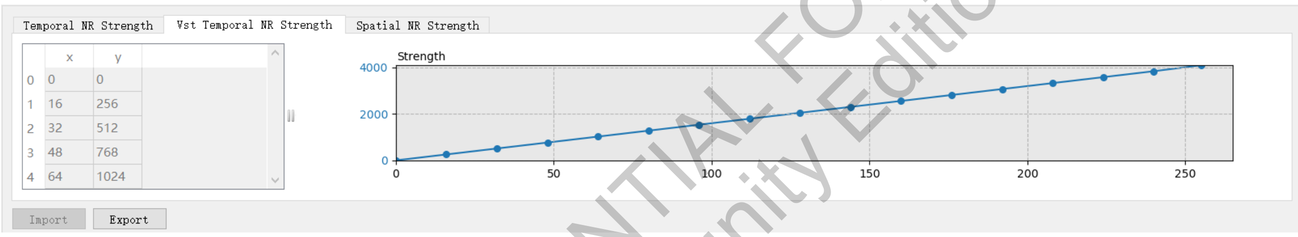


Figure 3-84 AiNr_Vst_Temporal_NR_Strength Parameter Configuration

☞ As shown in the above graph, the horizontal axis from left to right represents the static area to the motion area. The vertical axis represents spatial noise reduction strength, where a larger value indicates stronger spatial strength. It is recommended to maintain the default curve strength or fine-tune the default values.

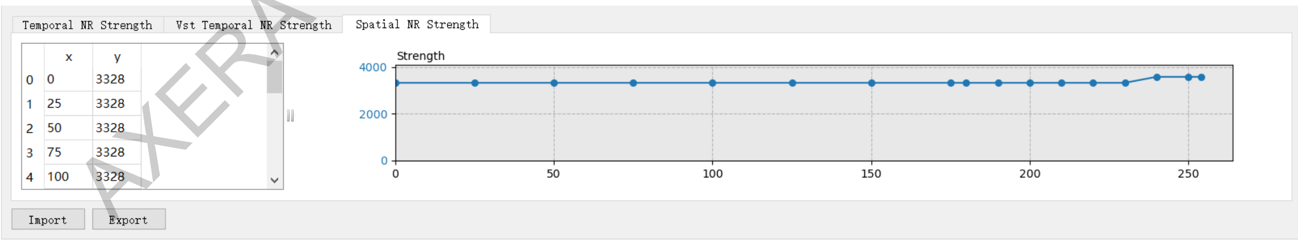


Figure 3-85 AiNr_Spatial_NR_Strength Parameter Configuration

☞ As shown in the above graph, the horizontal axis from left to right represents the static area to the motion area. The vertical axis represents spatial noise reduction strength, where a larger value indicates stronger spatial strength. It is recommended to have a smooth transition between the static and motion areas.

3.8.4 Model Naming

Description of General Model Naming

General Model												
Sensor Name	Model Type	Width (W)	Height (H)	Bit_Depth (bit)	CgMode	ISP1	Again (X)	IspGain	4-bit Number	11-bit Number	Date	Platform
Full name of the sensor, e.g. OS04A10, IMX334, and OS08A20	Indicates the primary type of the model. Common base types include: SDR and HDR. Most SDRs use the WBT model, and currently only HDR models utilize this form.	IO resolution width of the model	IO resolution height of the model	IO bit of the model, e.g. 10 bit, 12 bit, or 16 bit	When a sensor has both HCG and LCG modes, this distinguishes between them. If HCG is not available, it defaults to LCG.	Currently using 1 NPU core	The analog gain segment of the model, either as a range or a specific value. Ranges are indicated with a dash, such as A16X and A16-32X.	The ISP gain segment for the model, either as a range or a specific value. Ranges are indicated with a dash. If there is no ISP gain segmentation, it can be omitted.	For internal debugging		The release date of the model, such as 220114	Platform of the model, e.g. AX620A or AX620E

Example:

SC450AI_HDR_2688x1520_10b_LCG_ISP1_A8-32X_0000_00000648546_240119_AX620E.axmodel

This model represents:

- Sensor name: SC450AI
- Model type: HDR mode
- Model input/output image width: 2688 pixels
- Model input/output image height: 1520 pixels
- Model data bit depth: 10 bits
- Sensor working mode adapted by the model: LCG mode
- ISP1: Currently using 1 NPU core
- A8-32: Indicates the model is suitable for gain ranges of 8X-32X (Again)

- IspGain: This value is omitted, indicating that the model is suitable for the gain segment where IspGain is not activated, i.e., IspGain=0X
- 0000_00000648546: This is a marker value for internal debugging purposes.
- 240119: Indicates the model's release date is January 19, 2024.
- AX620E: Indicates that the corresponding chip platform for this model is AX620E.

Description of WBT Model Naming

WBT Model													
Sensor Name	Model Type	Width (W)	Height (H)	Bit_Depth (bit)	CgMode	ISP1	Again (X)	IspGain	4-bit Number	11-bit Number	MULTI X	Date	Platform
Full name of the sensor, e.g. OS04A10, IMX334, and OS08A20	Indicates the primary type of the model. Common base types include: SDR and HDR. Most SDRs use the WBT model, and currently only HDR models utilize this form.	IO resolution width of the model	IO resolution height of the model	IO bit of the model, e.g. 10 bit, 12 bit, or 16 bit	When a sensor has both HCG and LCG modes, this distinguishes between them. If HCG is not available, it defaults to LCG.	Currently using 1 NPU core	The analog gain segment of the model, either as a range or a specific value. Ranges are indicated with a dash, such as A16X and A16-32X.	The ISP gain segment for the model, either as a range or a specific value. Ranges are indicated with a dash. If there is no ISP gain segmentation, it can be omitted.	For internal debugging		X is the max. number of 2D/3D sub-models in the WBT model	The release date of the model, such as 220114	Platform of the model, e.g. AX620A or AX620E

- WBT model naming follows the regular model naming rules, but includes the additional name "MULTIX" due to containing multiple sub-models. Here, X represents the maximum number of 2D/3D sub-models in the WBT model. For example, if there are 3 3D sub-models and 4 2D sub-models in the WBT, then X would be 4.
- Naming rules for WBT's sub-models

  Mass production package version + Model type (2d/3d) + Model structure + Selected parameters

  Example: V0.2.8_2d_S1-R600C_iso76800_102400_L147_F4_C1_M1

  - V0.2.8: Indicates the mass production package version is V0.2.8
  - 2d: Indicates that the model is a 2D model
  - S1-R600C: Represents the structure model number of the model

- Iso76800_102400: Represents the current model's adapted gain range
- L147_F4_C1_M1: Represents the parameters used when selecting the model from the mass production platform. Here, L stands for luma, F stands for fine, C stands for coarse, and M stands for motion.

3.8.5 Model Integration Description

3.8.5.1 WBT Model Integration Configuration

```
{
/* tAutoParam */
{
    /* nAutoModelNum */
    2,
    /* tAutoModelTable[12] */
    {
        /* 0 */
        {
            /* tMata */
            {
                /* szModelPath[256] */
                "/opt/etc/models/aiisp/SC830AI_S1_360_3840x2160_10b_LCG_ISP1_A32X_I1-16X_0000_multi2_mass_pack_1710320831_240
                /* szModelName[256] */
                "SC830AI_S1_360_3840x2160_10b_LCG_ISP1_A32X_I1-16X_0000_multi2_mass_pack_1710320831_240313_ax620e.axmodel",
                /* szTemporalBaseNrName[256] */
                "0.3.0-Patch-VB1_3d_S1-R360_iso3200_25600_L147_F4_C5_M1",
                /* szSpatialBaseNrName[256] */
                "0.3.0-Patch-VB1_2d_S1-R360_iso3200_25600_L147_F6_C7",
                /* nHcgMode */
                0,
                /* nIsoThresholdMin */
                1600,
                /* nIsoThresholdMax */
                9600,
                /* nBiasIn2D[4] */
                {4096, 4096, 4096, 4096, /*0 - 3*/},
                /* nBiasIn3D[4] */
                {4096, 4096, 4096, 4096, /*0 - 3*/},
            },
            /* tParams */
            {
```


Figure 3-86 WBT Model Integration Configuration

3.8.5.2 Non-WBT Model Integration Configuration

```
/* tAutoParam */
{
    /* nAutoModelNum */
    2,
    /* tAutoModelTable[32] */
    {
        /* 0 */
        {
            /* tMeta */
            {
                /* szModelPath[256] */
                "/opt/etc/OS08B10_SDR_3840x2160_10b_HCG_ISP1_A16X_I24-64X_f000_00000199845_221214_AX650.axmodel",
                /* szModelName[256] */
                "OS08B10_SDR_3840x2160_10b_HCG_ISP1_A16X_I24-64X_f000_00000199845_221214_AX650.axmodel",
                /* nBiasIn[4] */
                {0, 0, 0, 0, /*0 - 3*/},
                /* nBiasOut[4] */
                {0, 0, 0, 0, /*0 - 3*/},
                /* nHcgMode */
                0,
                /* nIsoThresholdMin */
                1,
                /* nIsoThresholdMax */
                1000000,
            },
            /* tParam */
            {
                /* tNonSensParam */
                {
                    /* nParamGrpNum */
                    4,
                    /* nRefValStart[4] */
```

Figure 3-87 Non-WBT Model Integration Configuration

3.8.6 Auto parameter

Configure automatic mode parameters to switch between different model parameters based on varying gains in different environmental conditions.

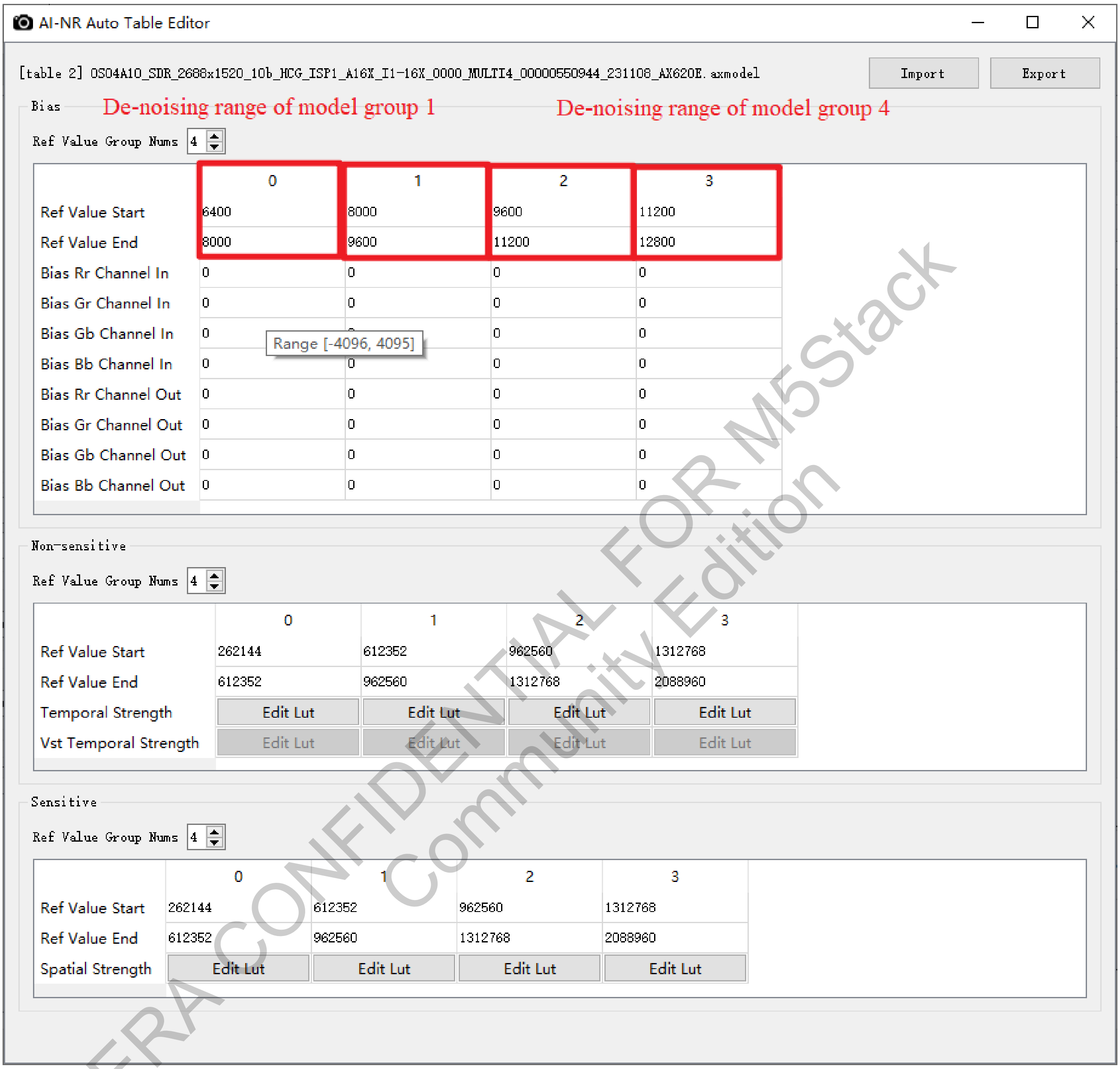


Figure 3-88 Automatic parameter configuration table

- Ref Value Start/End: Set the starting and ending gain points at which the model becomes effective. Taking the configuration in the above figure as an example, 6400 represents TotalGain=6400/100=64X, which corresponds to 36dB when converted to dB units.

- The meaning of Ref Value Start/End in Temporal/Spatial Strength is similar. Using the configuration in the above image as an example, if the Sensor's HCG/LCG = 4, then at TotalGain = 64X, Ref Value Start = 64×4×1024=262144.

3.9 Scene

3.9.1 Introduction

The Scene module is designed to provide users with the capability to configure the working mode of the ISP. It serves as a functional module that allows the TIISP to automatically switch to AIISP mode at a certain gain level.

3.9.2 Interface

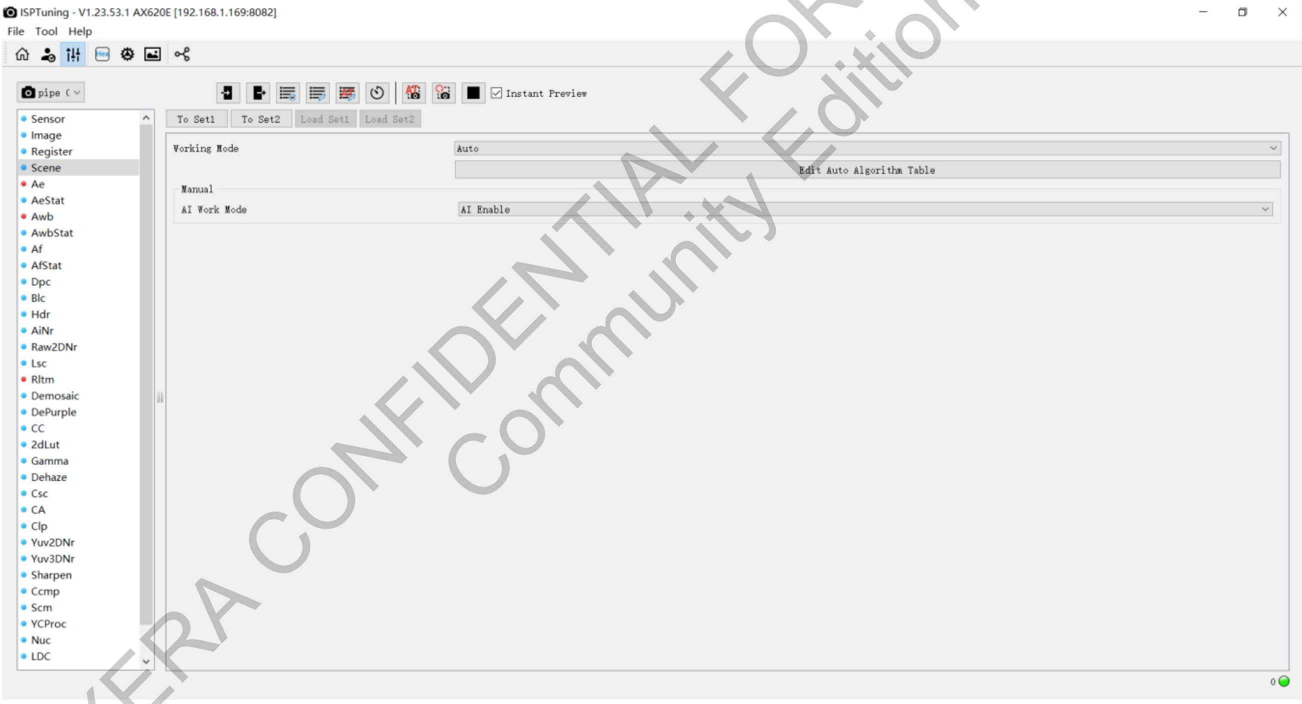


Figure 3-89 Scene

3.9.3 Parameter

Parameter	Description	Range
Working Mode	Auto/Manual working mode	Auto/Manua
Edit Auto Algorithm Table	Edit and modify automatic parameter configuration	/

Ref Value Start	Starting gain (TotalGain×1024)	0 ~ 4294967295
Ref Value End	Ending gain (TotalGain×1024)	0 ~ 4294967295
AI Work Mode	Manually configure AI enable	0~255

3.9.4 Debugging Steps

Assuming AIISP is enabled at 30dB, configuration can be done as per the diagram below. The parameter calculation process is as follows: 30dB = TotalGain (32X) = 32 × 1024 = 32768. In the table below, AI is disabled when in the range [1024, 32768], indicating TIISP mode, and AI is enabled in the range [32768, 4193280], indicating AI mode. Delta represents the smoothing parameter, and the default value can be used.

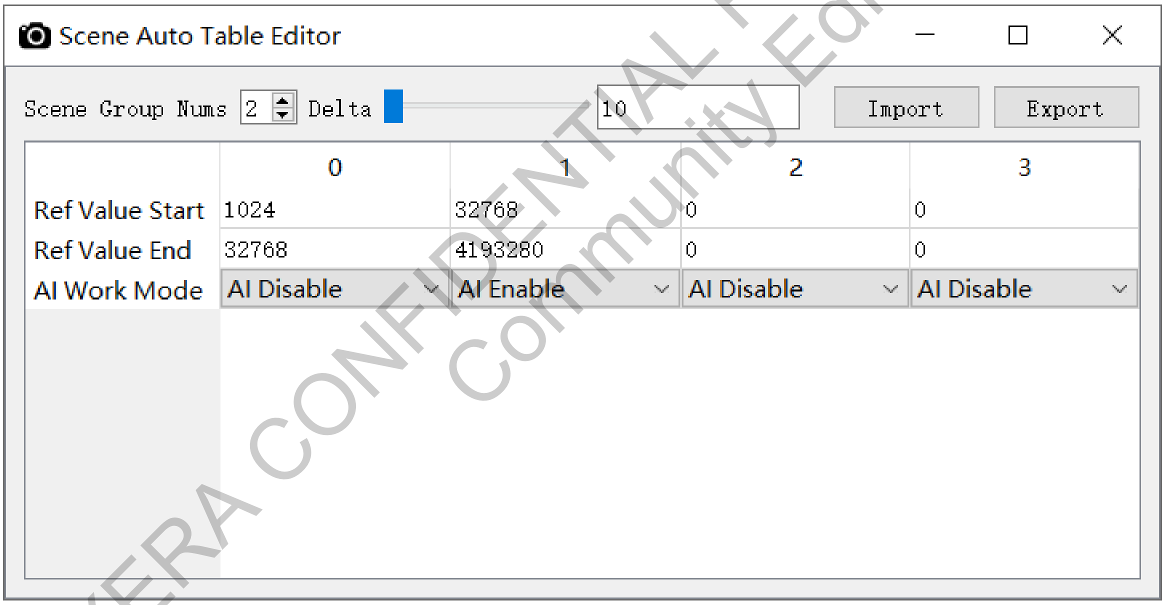


Figure 3-90 TIISP Switched to AIISP Configuration

3.10 Raw2DNr

3.10.1 Introduction

Raw2DNr: Raw domain 2D noise reduction module. It supports spatial noise reduction, edge preservation frequency separation, separate control of high-frequency noise and low-frequency noise, Gb and Gr channel noise reduction, noise reduction intensity control based on brightness, and support for receiving external motion mask input for separate noise reduction control in motion and static regions. Below is the algorithm process.

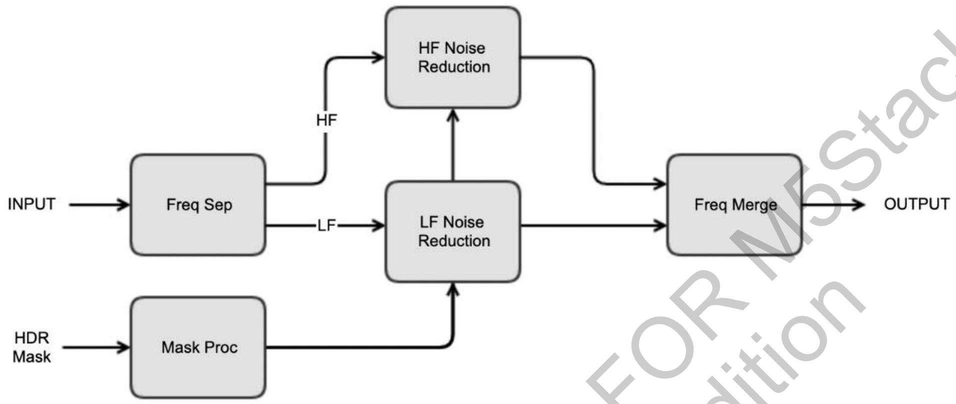


Figure 3-91 Raw2Dnr Handling Process

3.10.2 Interface

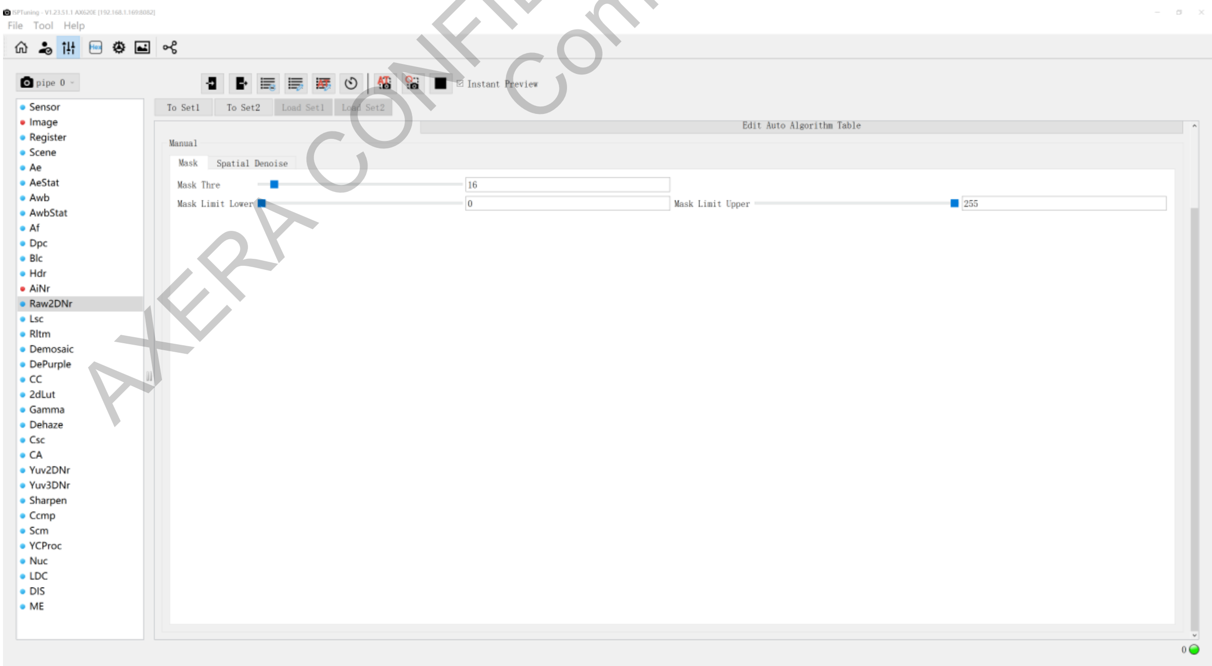


Figure 3-92 Raw2Dnr

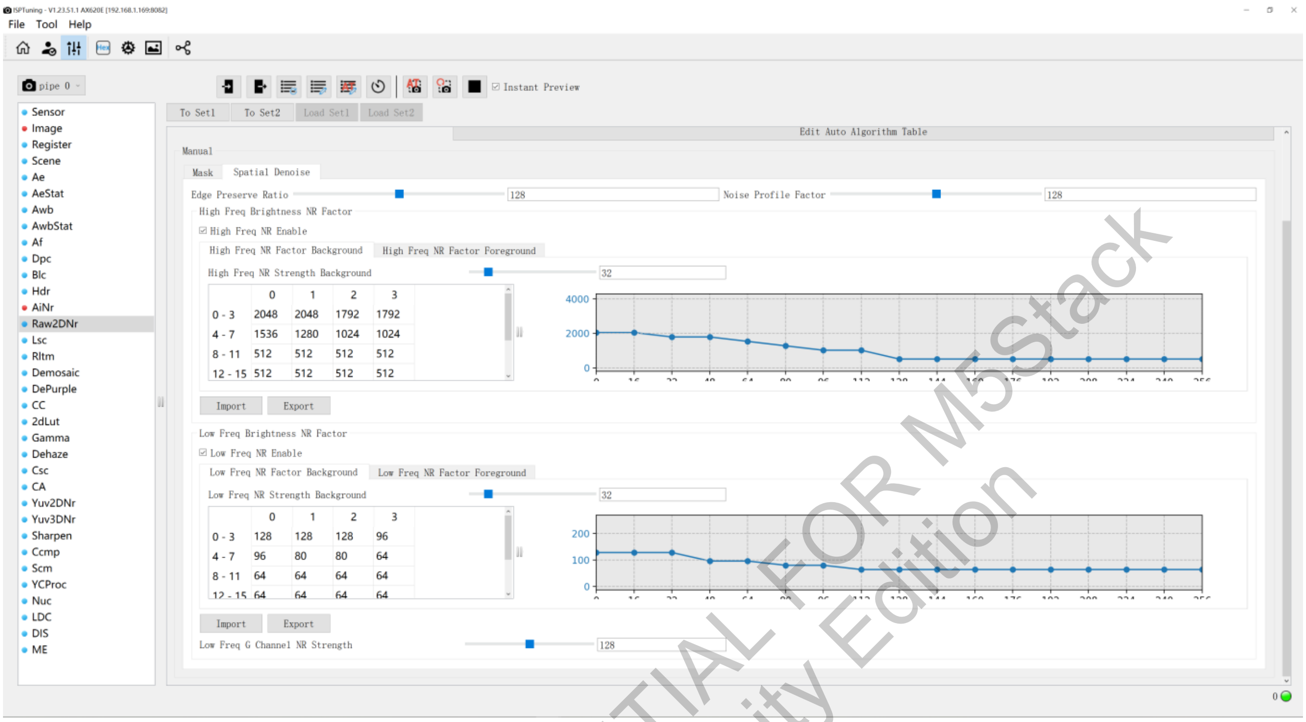


Figure 3-93 Raw2Dnr

3.10.3 Parameter

Parameter	Description	Range
Enable Raw2Dnr	Function switch, check to enable	0.1
Working Mode	Auto/Manual working mode	Auto/Manua
Lut Type	Linear/log mode, recommended to use Linear mode	
Lut Mode	SDR mode	/
	HDR mode	2DOL/3DOL
Edit Auto Algorithm Table	Edit and modify auto algorithm table configuration	/
Mask Thre	Mask threshold	0~255
Mask Limit Lower	Mask lower limit, recommended to set to 0	0~255
Mask Limit Upper	Mask upper limit, recommended to set to 255	0~255
Edge Preserve Ratio	Edge preservation ratio, the smaller the value, the more low-frequency proportion, the larger the value, the more high-frequency proportion	0~255

Parameter	Description	Range
NoiseProfileFactor	Noise coefficient, the larger the value, the weaker the noise reduction	0~255
High Freq NR Enable	High-frequency noise reduction function switch	0.1
High Freq NR Strength Background/Foreground	High-frequency noise reduction strength, the larger the value, the stronger the overall noise reduction	0~255
High Freq NR Factor Background/Foreground	High-frequency noise reduction strength adjusted with brightness for background/foreground, the larger the value, the stronger the noise reduction	0~4095
Low Freq NR Enable	Low-frequency noise reduction function switch	0~1
Low Freq NR Strength Background/Foreground	Low-frequency noise reduction strength adjusted with brightness, the larger the value, the stronger the noise reduction	0~255
Low Freq NR Factor Background/Foreground	Low-frequency noise reduction strength adjusted with brightness for background/foreground	0~255
Low Freq G Channel NR Strength	Gr, Gb channel noise reduction strength, the larger the value, the stronger the noise reduction	0~255

! In versions after 240822, the effective node count for the NR Factor Lut parameter has been optimized. For the linear type, the effective parameters have been reduced from 17 to 5 (counting from the left of the LUT table). For the log type, the effective parameters have been reduced from 17 to 15 (counting from the left of the LUT table).

Debugging Steps

Step 1: Adjust parameters to separate image frequency bands.

- Set High Freq NR Strength to (255, 255).
- Set Low Freq NR Strength to (0, 0).
- Adjust Edge Preserve Ratio until high-frequency noise is removed while preserving the edges adequately.
- If edge preservation is not ideal, decrease NoiseProfileFactor.

Step 2: Adjust non-masked areas.

1) Adjusting High-Frequency Part:

- Set High Freq NR Strength Background to 255.

- Adjust the LUT curve below High Freq NR Strength Background to adjust the noise reduction coefficients at different brightness levels.
- Lower the intensity of High Freq NR Strength Background to balance the overall effect.

2) Adjusting Low-Frequency Part:

- Set Low Freq NR Strength Background to 255.
- Adjust the LUT curve below Low Freq NR Strength Background to adjust the noise reduction coefficients at different brightness levels.
- Lower the intensity of Low Freq NR Strength to balance the overall effect.
- Adjust Low Freq G Channel NR Strength to balance the intensity between channels; it's recommended to set it to 128 if there are no obvious artifacts.

Step 3: Adjust masked areas.

- This part applies when there is an external Mask input, such as when the NPU inputs a motion Mask. In SDR mode with AI, only the High/Low Freq NR Factor Foreground parts are effective. Without an external Mask input, only the High/Low Freq NR Factor Background parameters are effective.
- In SDR mode with AI, High/Low Freq NR Strength Foreground/Background correspond to motion and static regions respectively. It's recommended to set Mask Thre between 16-32, usually set to 16, depending on the range of Mask data provided by the external NPU.
- In HDR mode, High/Low Freq NR Strength Foreground/Background correspond to short and long frames respectively, not motion and static regions. Same recommendations for Mask Thre apply as in SDR mode.

1) Adjusting High-Frequency Part:

- Set High Freq NR Strength Foreground to 255.
- Adjust the LUT curve in High Freq NR Factor Foreground to adjust the noise reduction intensity at different brightness levels.
- Lower the intensity of High Freq NR Strength to balance the overall effect.

2) Adjusting Low-Frequency Part:

- Set Low Freq NR Strength Foreground to 255.
- Adjust the LUT curve in Low Freq NR Factor Foreground to adjust the noise reduction intensity at different brightness levels.
- Lower the intensity of Low Freq NR Strength to balance the overall effect.

3.11 Lsc

3.11.1 Introduction

LSC (Lens Shading Correction) is a module aimed at correcting uneven distribution of luminance and color shading in images. Its functions include:

- Correcting luma shading to address uneven brightness at the edges and center of the image.
- Correcting color shading to address color deviations at the edges and center of the image.
- For LSC correction methods, please refer to *AX Image Calibration and Debugging Guide*.

3.11.2 Interface

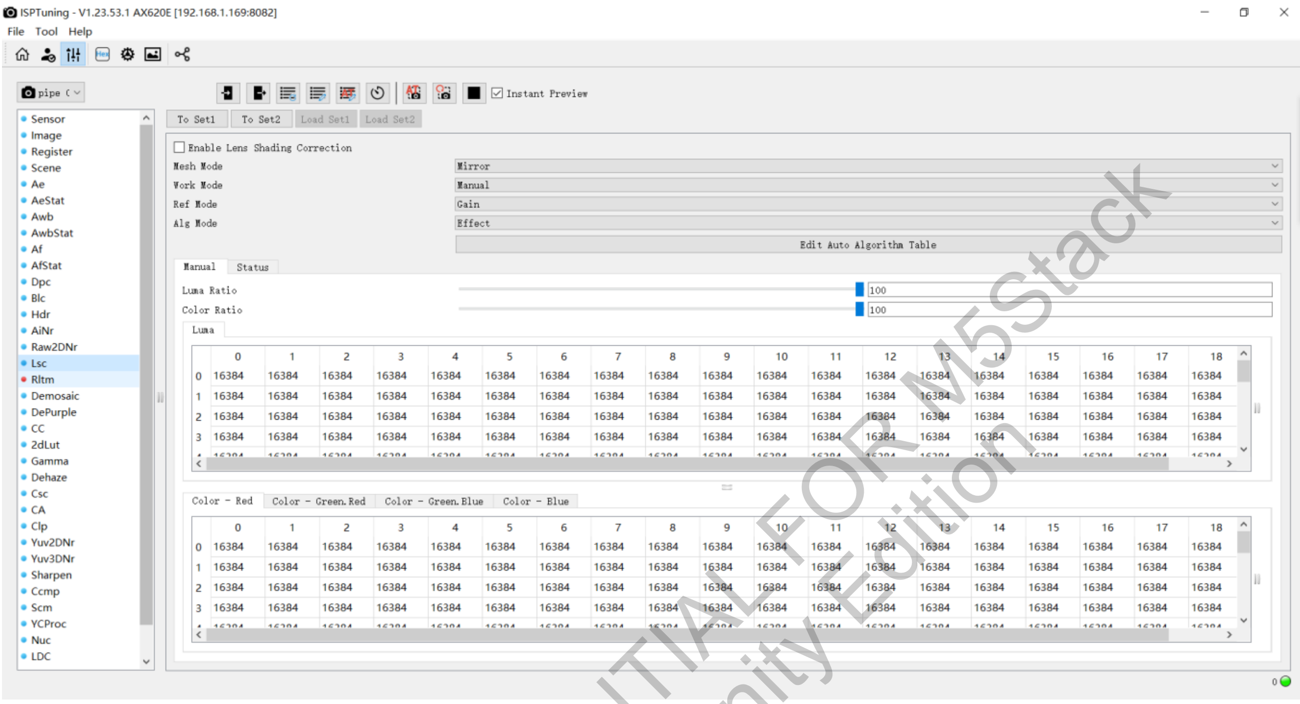


Figure 3-94 LSC Interface

3.11.3 Parameter

LSC parameters are derived from offline calibration.

Parameter		Description	Range
Mesh Mode	Normal	Normal correction grid 15H×19W	/
	Mirror	Mirrored correction grid 15H×19W	/
Work Mode	Manual/Auto	Manual/Automatic mode	/
Ref Mode	Gain/Lux	Gain/Lux as reference values	/
Alg Mode	Effect	Accurate mode, LSC table calculated for every frame	/
	Balance	Balanced mode, LSC table calculated every two frames	/
	Performance	Efficient mode, LSC table calculated every three frames	/
Edit Auto Algorithm Table	Allows editing of the automatic parameter configuration table		/

Luma Ratio	Luma correction intensity, higher values result in stronger LSC luma effect	0~100
Color Ratio	Color correction intensity, higher values result in stronger LSC color effect	0~100
Luma	Luminance correction intensity	Calibrated data
Color-Red	R channel correction intensity	
Color-Green.Red	GR channel correction intensity	
Color-Green.Blue	GB channel correction intensity	
Color-Blue	B channel correction intensity	

3.11.4 Auto mode

Parameter Description

- Working Mode
  - Description: Switches between auto/manual mode
  - Parameter
    - Manual: In manual mode, parameters can be freely adjusted.
    - Auto: In automatic mode, parameters are adjusted based on gain/luminance as reference values.
- Ref Mode
  - Choice of reference value type for the automatic strategy, which affects the meaning of Ref Val in the Auto Algorithm Table.
  - Parameter
    - Lux: In this mode, Ref Val in the Auto Algorithm Table is actually the Lux value. This parameter changes with the illuminance.
    - Gain: In this mode, Ref Val in the Auto Algorithm Table is actually the gain. This parameter changes with the gain.
- Ref Val:

■ Displays the current numerical value of Ref Val.

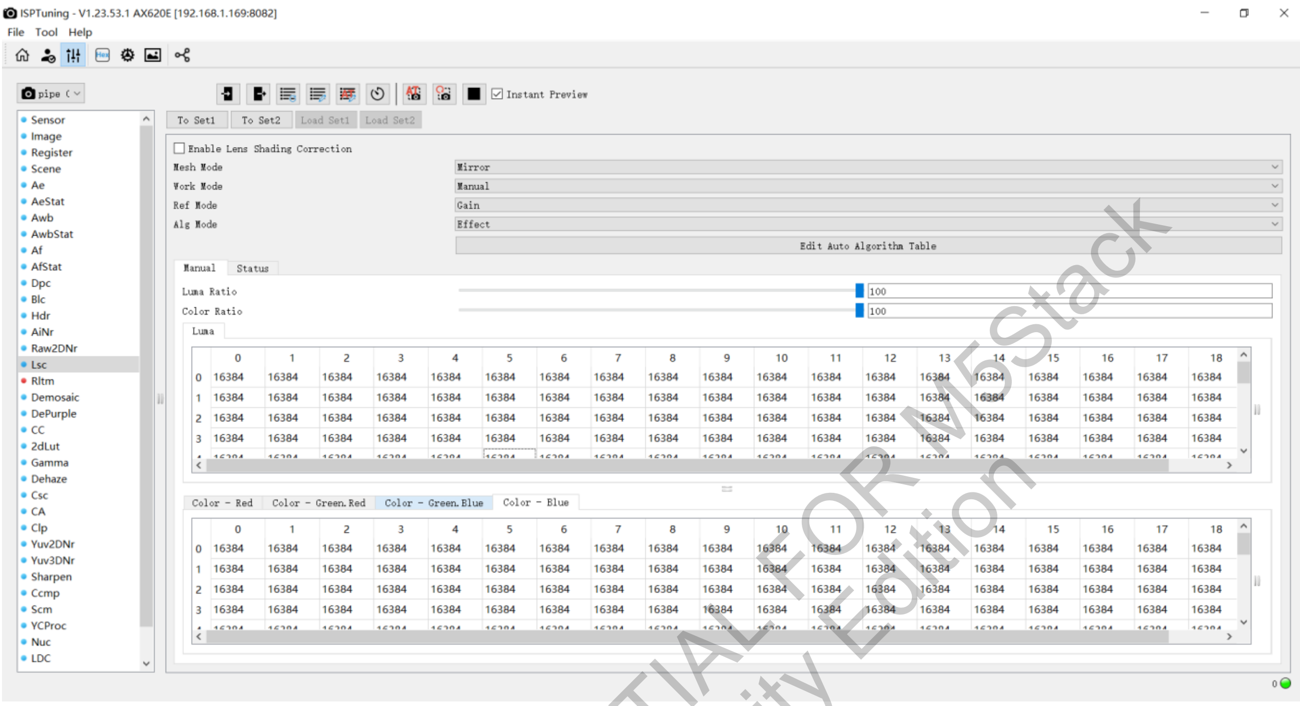


Figure 3-95 Lsc Auto Table

3.12 Rltm

3.12.1 Introduction

RLTM (Raw Local Tone Mapping) is a module that performs LTM in the raw domain. As a brightness adjustment module, RLTM enables both local and global tone mapping functions. It enhances the visibility of images by adjusting local brightness and contrast, while also addressing display issues in HDR scenes.

- On the MC620E platform, RLTM supports a maximum data width compression of 20 bits to 12 bits.
- It divides the image into windows for brightness adjustment, with window sizes of 128/256/512/1024/1024 supported. The maximum total number of windows is 16x12. RLTM utilizes a curve with 257 segments in a log_lut format.

- Support for histogram statistics, mean statistics, and log mean statistics for the brightness of each window.
- 257-segment log_lut for global brightness adjustment.
- Highlights suppression, backlight enhancement, and contrast enhancement.
- Local high-frequency detail retention/enhancement.
- Global low-frequency enhancement.

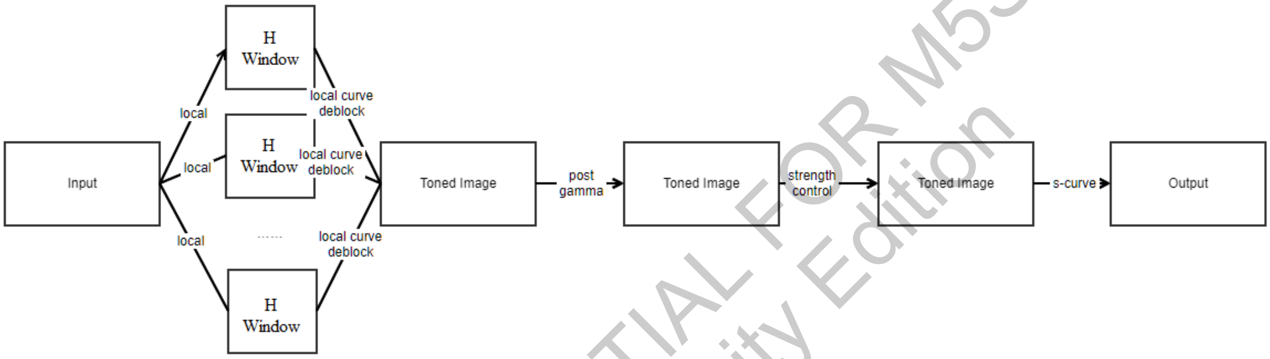


Figure 3-96 RLTM Processing Flowchart

Pre-processing Module

Pre-processing modules:

- The pre-processing modules of RLTM includes tuning of preceding modules such as AE, AWB, HDR, AINr, RAW2DNr, LSC, etc.
- Demosaic, Color Correction, and Gamma modules need to be at least initially tuned or use default configuration.

Automatic Adjustment Dependencies

The automatic adjustment of RLTM depends on dynamic parameters from other modules:

- Illuminance information: from AE
- Exposure time: from AE
- Analog gain: from AE

➢ Digital gain: from AE

➢ HCG status: from AE

3.12.2 Interface

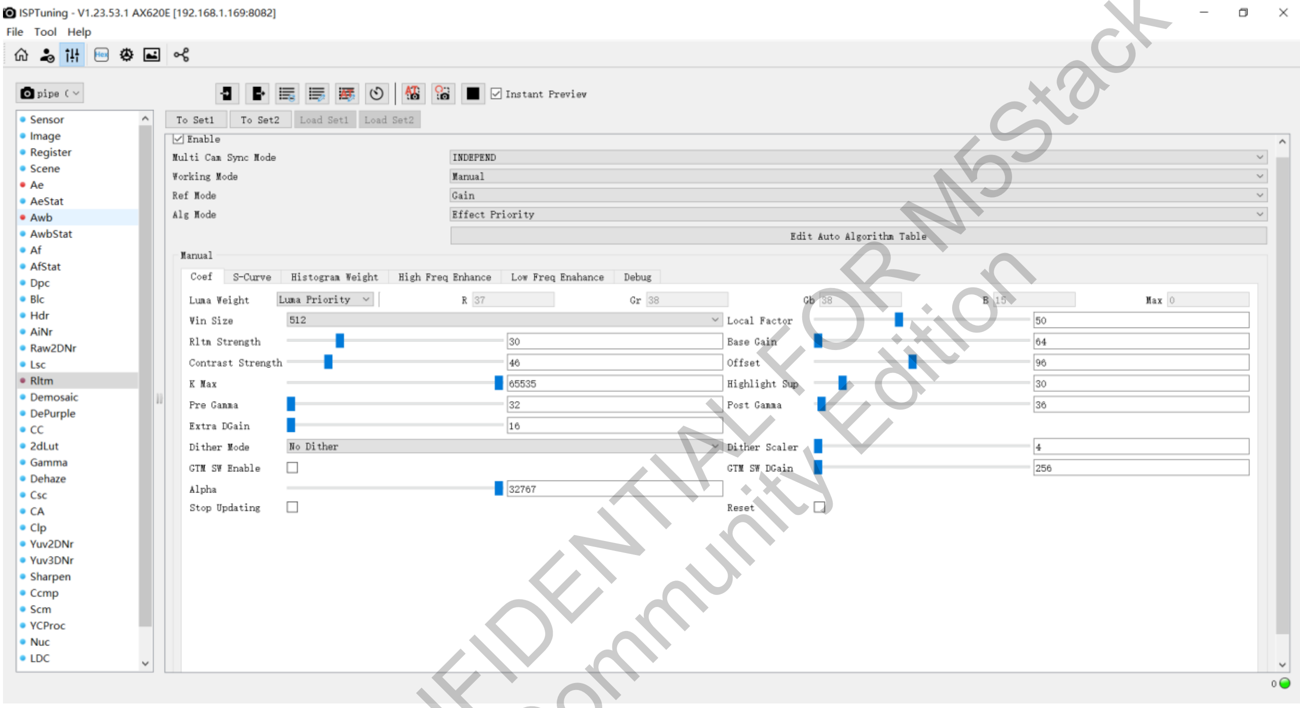


Figure 3-97 RLTM Interface

3.12.3 Parameter

Coef		
Parameter	Description	Range
Multi Cam Sync Mode	Multi-camera synchronization mode. INDEPEND/ MASTER SLAVE/ OVERLAP. Choose INDEPEND for single-camera mode.	/
Working Mode	Select manual/auto mode.	/
Ref Mode	Sets the automation strategy in Auto mode, either based on Lux or Gain.	/
Alg Mode	Effect Priority/Balance/Performance; Default: Effect Priority	

Edit Auto Algorithm Table	Edit the parameter table for Auto mode.	/
Manual-Coef		/
Luma Weight	Weight for calculating Luma inside the RLTM module using (R, Gr, Gb, B, max(R, Gr, Gb, B)). Ensure that luma_weight.sum() = 1 (Tuningtool interface value: 128). Where $luma = Weight\_R \times R + Weight\_Gr \times Gr + Weight\_Gb \times Gb + Weight\_B \times B + Weight\_max(R, Gr, Gb, B) \times max(R, Gr, Gb, B)$. ➢ Luma Priority: $Y = R \times 0.299 + G \times 0.587 + B \times 0.114$ standard calculation logic, prioritizing brightness. ➢ Balance: $Y = 1/3 \times R + 1/3 \times G + 1/3 \times B$ balanced between Luma Priority and Color Priority. ➢ Color Priority: Y = max(R, Gr, Gb, B) prioritizing color to avoid overexposure. ➢ User Defined: Custom ratios based on requirements.	Recommended to use Luma Priority.
Win Size	Reference range for brightness statistics windows. Smaller windows result in higher local contrast, while larger windows smooth out brightness transitions. Recommended: 512 for 2M/4M resolution sensors, 1024 for 4K resolution sensors.	{128, 256, 512, 1024}
Local Factor	Factor for adjusting local-global proportions. Larger values result in higher local contrast, while smaller values result in higher global contrast.	0~128
Rltm Strength	Strength value for RLTM. Configured as 0, AI-RLTM is disabled, using only the original image before AI-RLTM processing. Configured as 128, AI-RLTM is at its maximum strength, using only the image after AI-RLTM processing.	0~128
Base Gain	When mixing with the original image, pre-multiply the original image by base gain before fusion. When rltm strength is 128, indicating no fusion with the original image, this parameter has no effect. When rltm strength is less than 128, the higher the base	1~65535

	gain, the higher the final image brightness. A value of 64 represents 1x gain.	
Contrast Strength	Coefficient for different brightness interval ratios. Higher values result in higher local contrast, but excessive contrast may cause unnatural brightness transitions like halos.	0~255
offset	Minimum brightness for histogram weight statistics. Pixels with brightness lower than the offset have reduced weight. Higher offset values decrease pixel weight in more areas, reducing the likelihood of overexposure but lowering overall image brightness. Recommended values: ➢ SDR 10-bit: 96 ➢ HDR 10-bit: 77 Adjust around theoretical values based on actual results.	0~211
K Max	Limiting factor for brightness and contrast enhancement. Larger values restrict the enhancement less, resulting in higher local contrast and brightness. Smaller values limit brightness adjustments, leading to poorer visibility in dark areas. Larger k_max for less limited brightness adjustment and higher local contrast and brightness; smaller k_max for brightness multiplier and less ideal visibility in dark areas.	1~65535
Highlight Sup	High highlight suppression. Higher values darken the image, affecting low-light areas as well.	0~255
PreGamma	Overall brightness adjustment, particularly affecting dark areas. Larger values darken dark areas; smaller values brighten them.	32~255
PostGamma	Overall brightness adjustment, particularly affecting bright areas. Larger values darken bright areas; smaller values brighten them.	32~255
Extra Dgain	Digital gain (does not affect AI-RLTM functionality). Increases overall image brightness. Larger values result in more significant brightness enhancement, but	16~255

<table>
<tr><td></td><td colspan="2">excessive enhancement is not recommended. Increasing gain by Extra DGain/16 times.
Default value: Extra Dgain = 16 for 1x, maintaining the original brightness.</td><td></td></tr>
<tr><td rowspan="2">Dither Mode</td><td>No Dither</td><td>Generally used to counteract quantization step texture. Not typically activated under normal conditions.</td><td>0/1</td></tr>
<tr><td>Enable Dither</td><td>Enable dither noise.</td><td>0/1</td></tr>
<tr><td>Dither Scaler</td><td colspan="2">Intensity of high-frequency pulsating random noise. Larger values result in more noticeable random noise added.</td><td>0~65535</td></tr>
<tr><td>GTM SW Enable</td><td colspan="2">Enable GTM SW enable switch. When enabled, AI-RLTM functionality is disabled.</td><td>0/1</td></tr>
<tr><td>GTM SW Dgain</td><td colspan="2">Digital gain (affects AI-RLTM functionality). Higher values result in higher brightness, disabling contrast enhancement in AI-RLTM.</td><td>256~65535</td></tr>
<tr><td>Alpha</td><td colspan="2">Blend ratio of the current computed curve with the curve used in the previous frame, controlling the convergence rate of RLTM. Default: 512.</td><td>0~65535</td></tr>
<tr><td>Stop Updating</td><td colspan="2">Stop calculating updates. Typically left unchecked.</td><td>0/1</td></tr>
<tr><td>Reset</td><td colspan="2">Reset RLTM calculates updates per frame.</td><td>0/1</td></tr>
</table>

Win Size

- Spatial reference range. Options include 128, 256, 512, 1024, 2048. For performance reasons, it is recommended to use 512 for 4M resolution and 1024 or higher for 8M resolution.

- Effect: The smaller the window, the higher the local contrast (as shown in the left image below), and the larger the window, the more natural the image transition (as shown in the right image below).

Figure 3-98 Win Size Effect

Local Factor

➢ Local contrast enhancement strength. AI-RLTM has two contrast enhancements: local and global. Local Factor adjusts the ratio between local and global contrast. Larger values increase local contrast, while smaller values increase global contrast.

➢ Effect: For example, when Local Factor = 0 (bottom left image), the weight of global contrast is high, resulting in lower visibility of details in dark areas like the black cloth. However, when Local Factor = 128 (bottom right image), the weight of local contrast is high, increasing the visibility of details in the black cloth, and the black blocks on the color checkerboard are darker and more distinct.

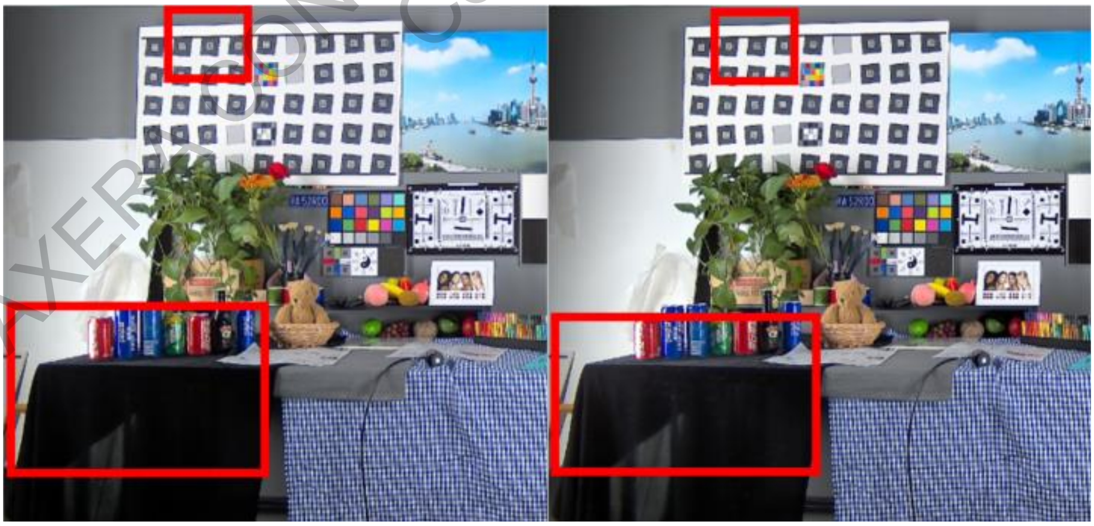


Figure 3-99 Local Factor Effect

K Max

- Maximum brightness multiplier. Range: [1, 65535].

- Effect: When AI-RLTM enhances local contrast and brightness, it multiplies the original image by a certain factor. K Max limits the maximum brightness gain.

- A larger K Max allows more freedom in brightness adjustment (as shown in the right image below), while a smaller K Max limits brightness enhancement, leading to poorer visibility in dark areas (as shown in the left image below). In the example below, as K Max increases, the limitation on brightness enhancement gradually decreases, resulting in improved visibility in dark areas near the plant.

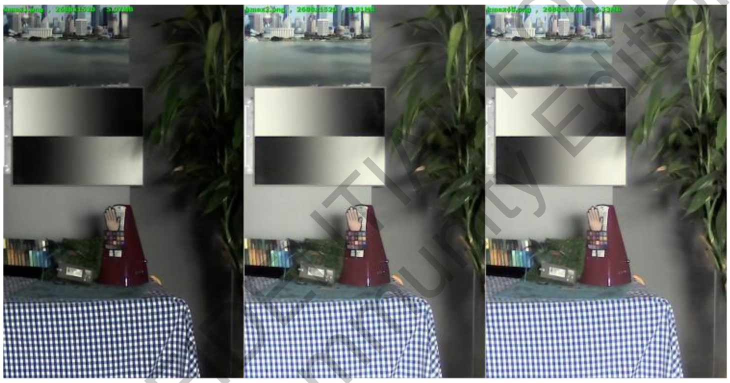


Figure 3-100 K Max Effect

Highlight Sup

- Highlight suppression. Higher values darken the image, affecting both high and low-light areas. Range: [0, 255].

Figure 3-101 Highlight Sup Effect

Pre Gamma

- Overall brightness adjustment, particularly affecting dark areas. Range: [0, 255], 32 by default.
- Larger values darken dark areas; smaller values brighten them.

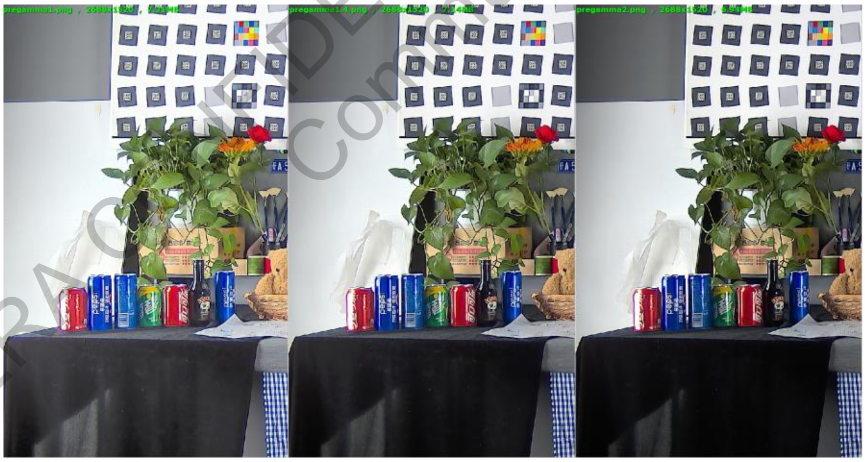


Figure 3-102 Pre Gamma Effect

Post Gamma

- Overall brightness adjustment, particularly affecting bright areas. Range: [32, 255].
- Effect: Larger values darken bright areas; smaller values brighten them.

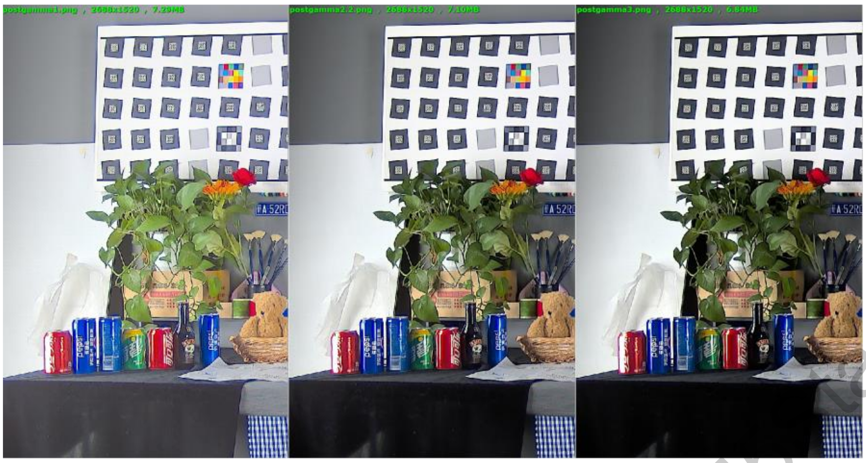


Figure 3-103 Post Gamma Effect

Extra DGain

- Digital gain. Range: [16, 255], 16 by default, recommend not adjusting unless necessary.
- Effect: Increases overall image brightness. Larger values result in more significant brightness enhancement (as shown in the right image below), with the enhancement factor being Extra DGain/16 times.

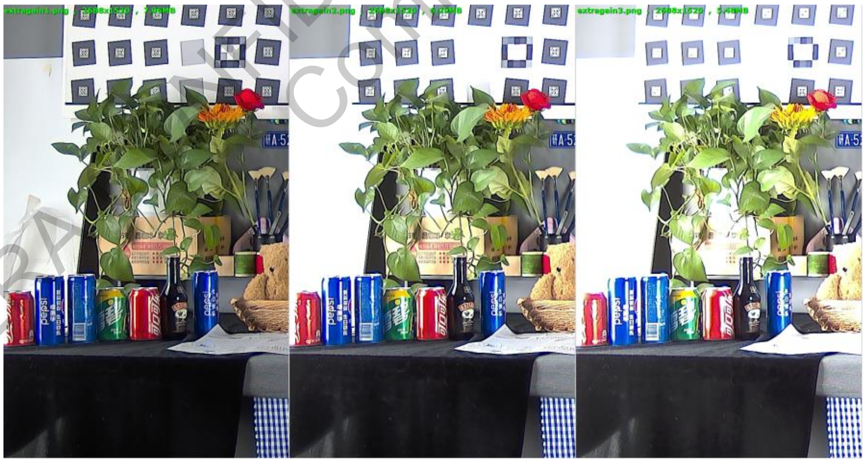


Figure 3-104 Extra Dgain Effect

Dither Mode

- Choose whether to enable dither noise and select where to add dither. Recommended not to enable.

Dither Scaler

- Add random noise to the entire image. Larger Dither Scaler for more pronounced noise. Usually used to counteract quantization artifacts, it is recommended not to enable it under normal circumstances. Range: [0, 65535].

- Effect: Increases random noise in the image, as shown in the magnified area within the red box in the example image below.

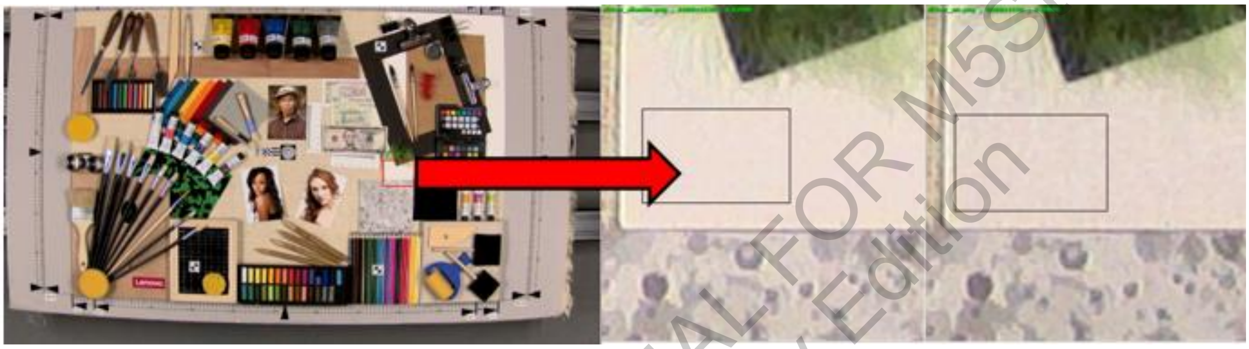


Figure 3-105 Dither Scaler Effect

GTM SW Enable

- GTM SW enable switch. Enabling this module is equivalent to disabling RLTM functionality.

GTM SW DGain

- When GTM SW Enable is checked, GTM function is enabled, equivalent to disabling RLTM functionality. RLTM module serves as a digital gain module. Range: [256, 65535].

- Effect: Higher values result in higher brightness.

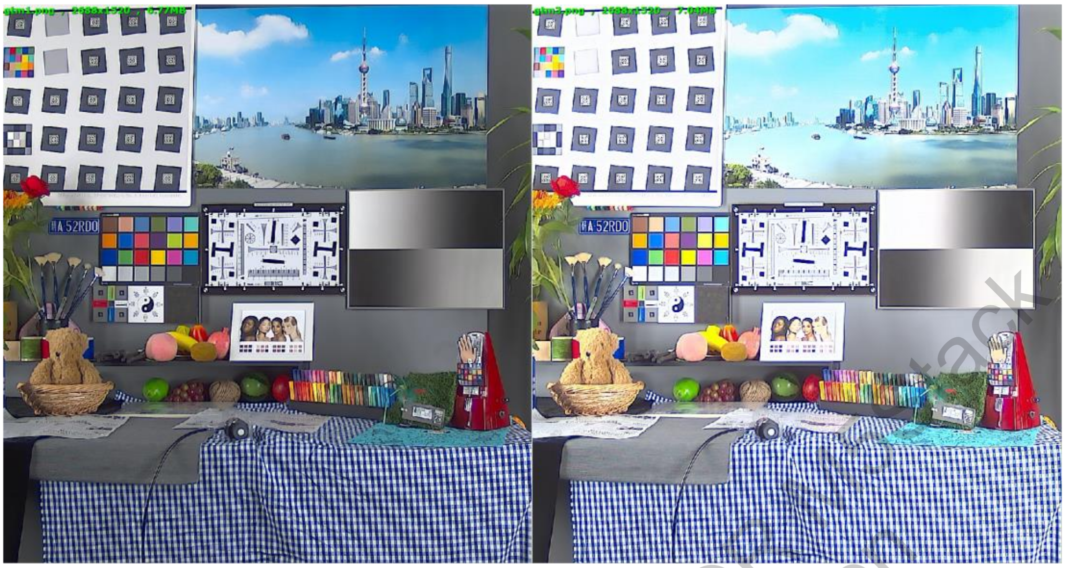


Figure 3-106 GTM_SW_DGain Effect

Alpha

Blend ratio of the current computed curve with the curve used in the previous frame. Affects the convergence rate of RLTM. Default: 512. Recommended not to modify this value.

Reset

RLTM calculates updates per frame. Default: Off. Can be turned on for manual debugging.

Stop Updating

Stop RLTM from calculating updates. Default: Off.

S-Curve

Adjust contrast for specific brightness levels by using grayscale mapping. Can be used to enhance brightness in dark areas, but exaggerated S-curve may lead to issues like increased noise in dark areas and reduced contrast in other brightness intervals.

- shadow_point: Threshold point for the shadow region.
- shadow_strength: Strength of enhancement or suppression in the shadow region.

- highlight_point: Threshold point for the highlight region.
- highlight_strength: Enhancement or suppression in the highlight region.

☞ Start with linear interpolation before adjusting the S-Curve after tuning the RLTM basic module. The S-Curve can be used to enhance brightness in shadow regions, but be cautious of exaggerating the curve, which can lead to increased noise in dark areas and decreased contrast in other brightness regions.

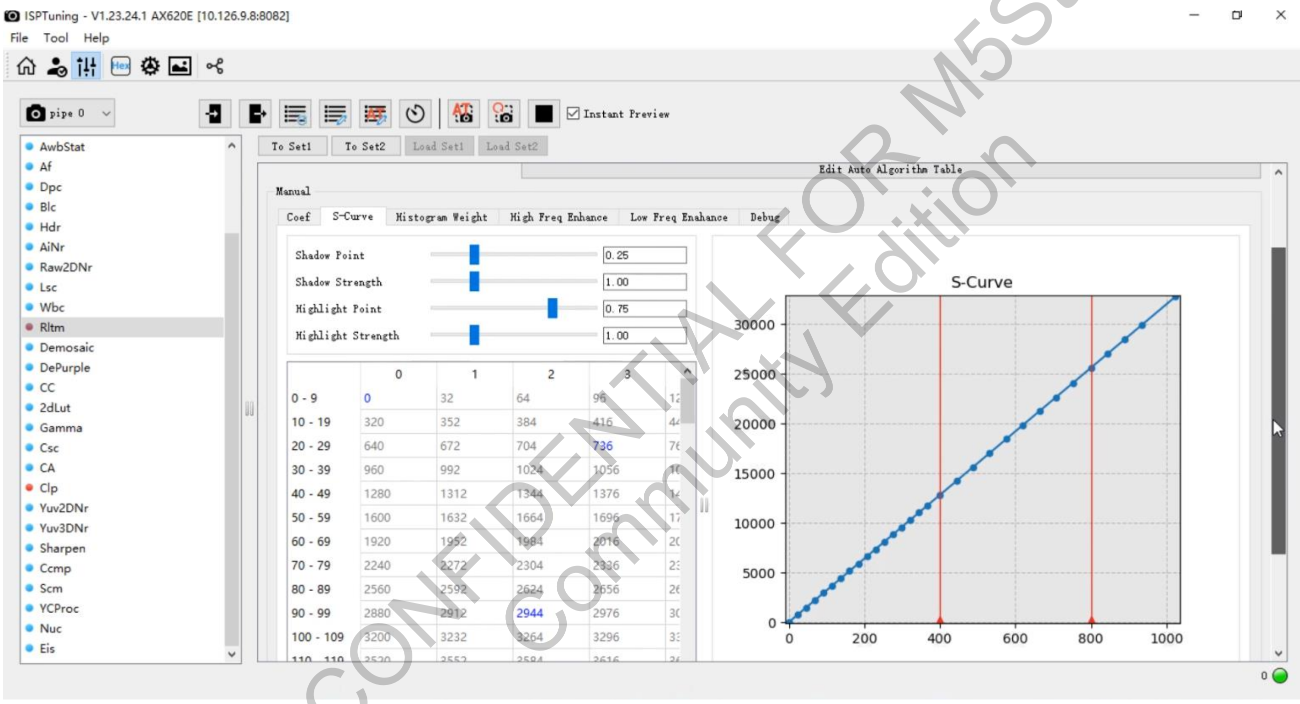


Figure 3-107 S-Curve

S-Curve		
Parameter	Description	Range
Shadow Point	Threshold point for the shadow region. 0.25 by default.	0~1
Shadow Strength	Enhancement or suppression in the shadow region. 1 by default.	0~4
Highlight Point	Threshold point for the highlight region. 0.75 by default.	0~1

Highlight Strength	Enhancement or suppression in the highlight region. 1 by default.		0~4
Control Points	Region I	Number of controlling points in Region I	1~50
	Region II	Number of controlling points in Region II	1~50
	Region III	Number of controlling points in Region II	1~50
Cubic	Enables the S-Curve to be displayed using cubic spline interpolation		0 1
Linear	Enables the S-Curve to be displayed using linear interpolation		3 1

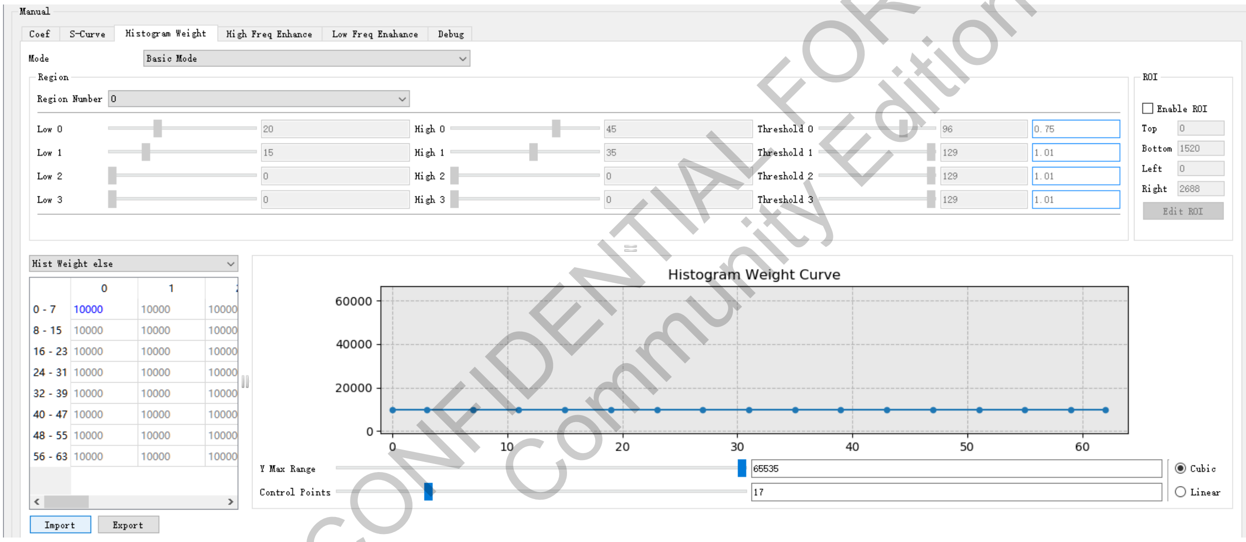


Figure 3-108 Histogram Weight

Histogram Weight			
Parameter	Description		Range
mode	Basic Mode	Basic Mode Windows that do not meet any region condition (Flag=0) apply HistWeight Else. Windows that meet the conditions of region1 apply HistWeight 1.	/

		Windows that meet the conditions of region2 apply HistWeight 2. Windows that meet the conditions of region3 apply HistWeight 3. Windows that meet the conditions of region4 apply HistWeight 4. These conditions can overlap.	
	Advanced Mode	In this mode, you have more flexibility to customize the mapping between Flag and HistWeight. It allows for the addition of up to 16 curves.	/
Region Number	Number of enabled regions. This parameter controls the number of regions in auto mode.		0~4
Low/high	Threshold values for each region, corresponding to the x-axis of the histogram weight curve.		0~62
Threshold	Proportion threshold for each region. It determines whether the window is classified based on the proportion of pixels falling within the brightness range.		0~129
Y Max Range	Maximum value for the Y-axis display range of histogram weight curve.		0~65535
Control Points	Number of control points for adjusting the histogram weight curve.		4~63
Enable ROI	Enables configuration of individual histogram weights for specific ROI. You can edit ROI coordinates by importing an image and selecting the area.		
Debug	Allows viewing of block information, displaying the Flag information of each window in the upper-left corner. Supports importing and exporting images for easy identification of regions of interest based on Flag status.		

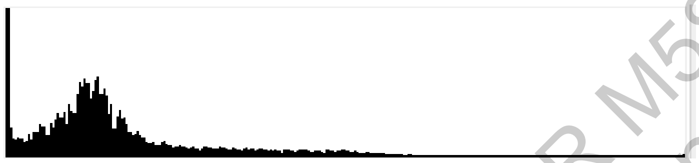
The specific weight for each brightness interval are divided into 63 segments, numbered from 0 to 62 to represent increasing brightness. The data in the table on the left corresponds to the data in the curve on the right. It is recommended to use the curve for coarse adjustments and the table for finer adjustments. When increasing the weight of a brightness interval, more dynamic range is allocated to pixels in that brightness interval, leading to an increase in local contrast. However, this may result in compression of the dynamic range in other brightness intervals.

- Region Number: The number of enabled intervals, ranging from a minimum of 0 to a maximum of 4. Note: In “auto” mode, this parameter controls the number of regions.

- Low/high: The brightness threshold for each interval, with a range of [0, 62], corresponding to the horizontal axis of the histogram weight curve.
- Threshold: The proportion threshold for each interval, determining whether the window is classified based on the proportion of pixels falling within the brightness interval.

Example 1: Filtering windows with low brightness

Low=0; high=40; threshold=0.7



In this case, if pixels with brightness lower than 40 in a window account for more than 70%, the condition is met. Obviously, the overall brightness of the window is low, so a histogram weight for brightening can be configured.

Example 2: Filtering windows with high brightness

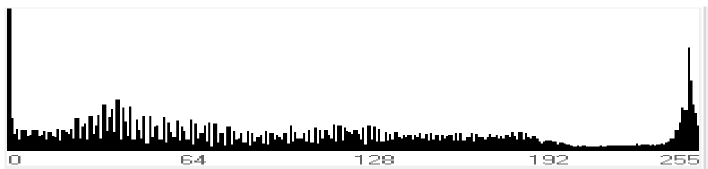
Low=30; high=62; threshold=0.7

In this case, if pixels with brightness higher than 30 in a window account for more than 70%, the condition is met. Obviously, the overall brightness of the window is high, so a histogram weight for darkening can be configured.

Example 3: Filtering windows with large brightness contrast (backlit face)

Low1=0; high1=20; threshold0=0.3;

Low2=50; high2=62; threshold1=0.3;



In this case, if pixels with brightness lower than 20 account for more than 30% and pixels with brightness higher than 50 account for more than 30% in a window, the condition is met. Corresponding histogram weights can be configured accordingly.

Each window can simultaneously meet multiple interval conditions, dividing all windows into 2^n categories based on the proportion of windows that meet the conditions. Up to 16 categories can be defined.

- Debug: View block information.

displaying the Flag information of each window in the upper-left corner. Supports importing and exporting images for easy identification of regions of interest based on Flag status.

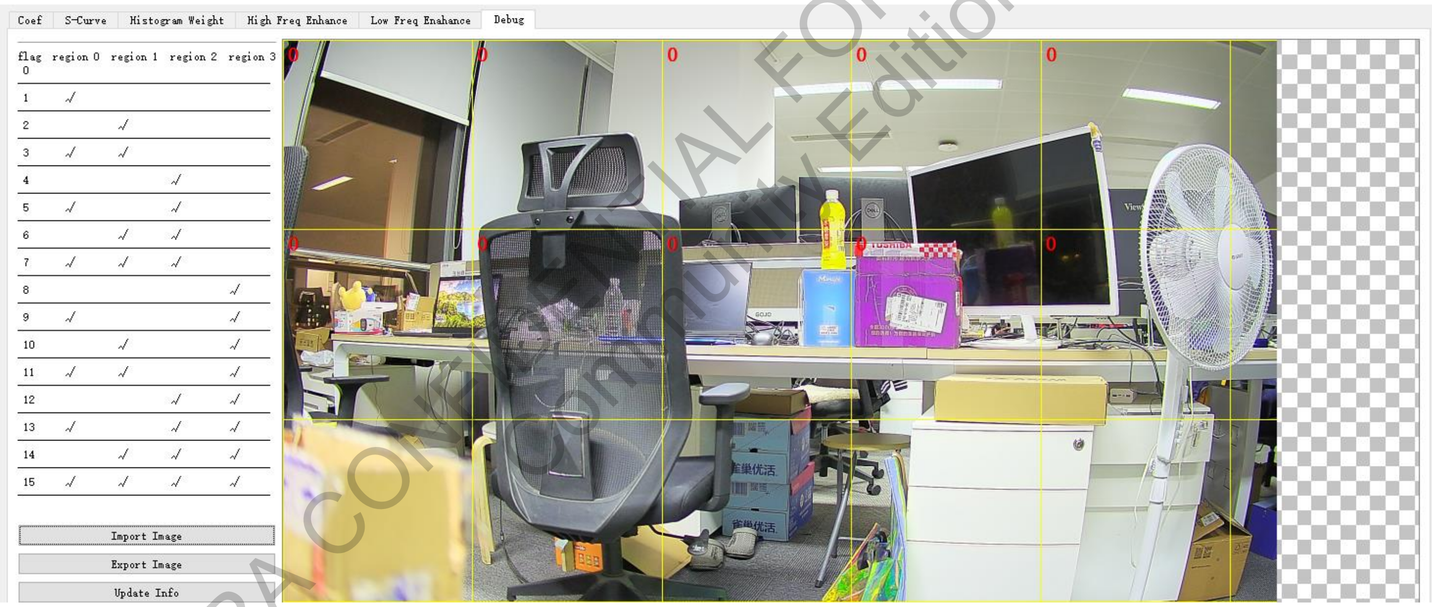


Figure 3-109 Debug

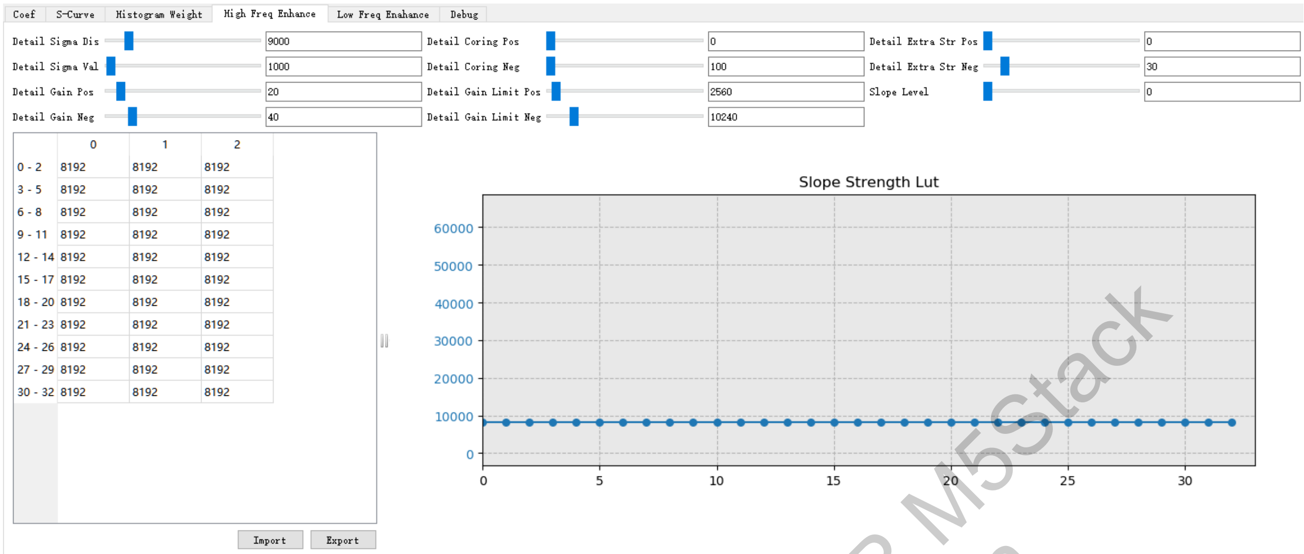


Figure 3-110 High Freq Enhance

Parameter	Description	Range
Detail Sigma Dis	Spatial filtering coefficient for detail enhancement	0~65535
Detail Sigma Val	Value filtering coefficient for detail enhancement	0~65535
Detail Gain Pos	Positive detail enhancement	0~255
Detail Gain Neg	Negative detail enhancement	0~255
Detail Coring Pos	Positive detail suppression	0~65535
Detail Coring Neg	Negative detail suppression	0~65535
Detail Gain Limit Pos	Positive detail enhancement limit, larger value means smaller limit	0~65535
Detail Gain Limit Neg	Negative detail suppression limit, larger value means smaller limit	0~65535
Detail Extra Str Pos	Specified positive detail enhancement intensity	0~65535
Detail Extra Str Neg	Specified negative detail enhancement intensity	0~65535
Slope Level	Gradient control coefficient Higher slope retains details better. Lower slope retains details poorly.	0~65535
Slope Strength Lut	Adaptive gradient control, adjusts detail strength based on the slope of the current position curve	0~65535

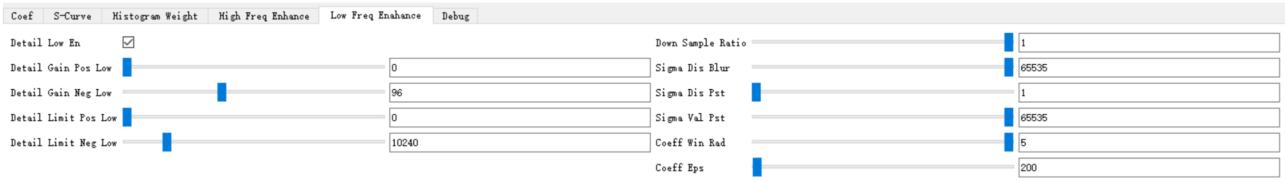


Figure 3-111 Low Freq Enhance

Low Freq Enhance		
Parameter	Description	Range
Detail Low En	Low-frequency enhancement switch	0/1
Down Sample Ratio	Low-pass filtering sampling window size 0: Output H/16×W/16 1: Output H/32 × W/32	0/1
Detail Gain Pos Low	Positive low-frequency enhancement	0~255
Detail Gain Neg Low	Negative low-frequency enhancement	0~255
Detail Limit Pos Low	Positive low-frequency enhancement limit, larger value means smaller limit	0~65535
Detail Limit Neg Low	Negative low-frequency suppression limit, larger value means smaller limit	0~65535
Sigma Dis Blur	Low-frequency enhancement anti-temporal motion parameter	0~65535
SigmaDis Pst	Low-frequency enhancement spatial filtering coefficient for detail extraction	0~65535
Sigma Val Pst	Low-frequency enhancement value filtering coefficient	0~65535
Coeff Win Rad	Low-frequency extraction window	0~5
Coeff Eps	Low-frequency filtering parameter, smaller value results in more natural low-frequency enhancement	0~65535

3.12.4 Debugging Steps

1. Rough adjustment of overall brightness:

   a) Adjust the overall image brightness through post_gamma and Highlight Sup.

   b) Adjust Rltm Strength and Base Gain correspondingly to achieve the desired intensity, ensuring that the overall brightness is within a reasonable range.

c) Repeat steps a and b to roughly adjust the overall brightness, ensuring that the distribution of light and dark areas is relatively appropriate.

2. Adjusting detail enhancement:

a) Adjust Slope Strength Lut and Slope Level to preserve details.

b) Further adjust Detail Extra Str to enhance overall details as needed.

c) Positive and negative details can be adjusted separately.

3. Adjusting low-frequency details:

a) Adjust Detail Gain Pos/Neg Low parameters to adjust the strength of low-frequency enhancement.

b) Adjust Sigma Dis Blur to balance the contrast between moving and static areas.

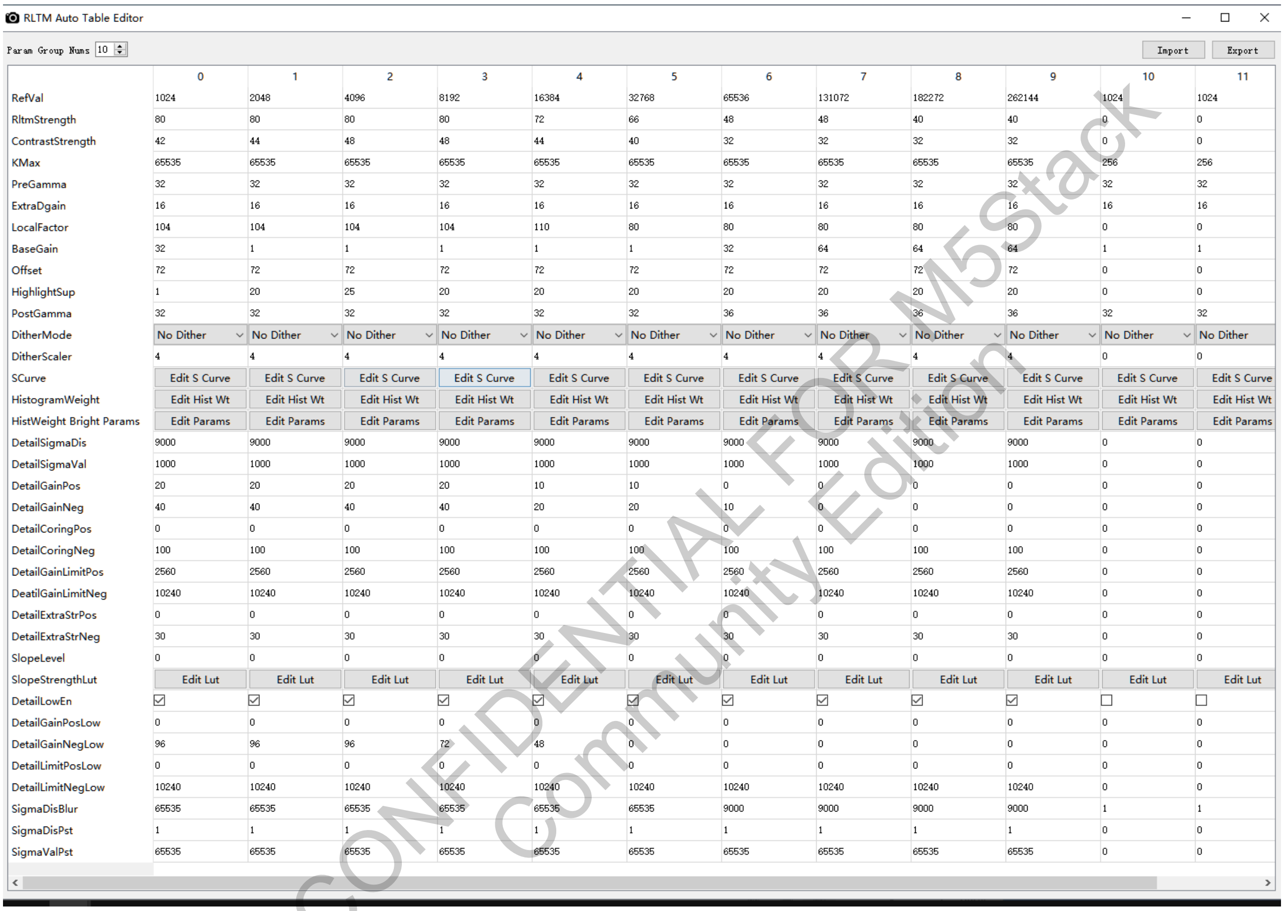
c) Positive and negative details can be adjusted separately.

4. Global brightness adjustment:

When adjusting the overall brightness, use S-Curve for adjustment, preferably as the final step in tuning.

3.12.5 Auto mode

Parameter Description



RLTM Auto Table Editor

Param Group Nums 10

Import Export

	0	1	2	3	4	5	6	7	8	9	10	11
RefVal	1024	2048	4096	8192	16384	32768	65536	131072	182272	262144	1024	1024
RltmStrength	80	80	80	80	72	66	48	48	40	40	0	0
ContrastStrength	42	44	48	48	44	40	32	32	32	32	0	0
KMax	65535	65535	65535	65535	65535	65535	65535	65535	65535	65535	256	256
PreGamma	32	32	32	32	32	32	32	32	32	32	32	32
ExtraDgain	16	16	16	16	16	16	16	16	16	16	16	16
LocalFactor	104	104	104	104	110	80	80	80	80	80	0	0
BaseGain	32	1	1	1	1	1	32	64	64	64	1	1
Offset	72	72	72	72	72	72	72	72	72	72	0	0
HighlightSup	1	20	25	20	20	20	20	20	20	20	0	0
PostGamma	32	32	32	32	32	32	36	36	36	36	32	32
DitherMode	No Dither	No Dither	No Dither	No Dither	No Dither	No Dither	No Dither	No Dither	No Dither	No Dither	No Dither	No Dither
DitherScaler	4	4	4	4	4	4	4	4	4	4	0	0
SCurve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve	Edit S Curve
HistogramWeight	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt	Edit Hist Wt
HistWeight Bright Params	Edit Params	Edit Params	Edit Params	Edit Params	Edit Params	Edit Params	Edit Params	Edit Params	Edit Params	Edit Params	Edit Params	Edit Params
DetailSigmaDis	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	0	0
DetailSigmaVal	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	0	0
DetailGainPos	20	20	20	20	10	10	0	0	0	0	0	0
DetailGainNeg	40	40	40	40	20	20	10	0	0	0	0	0
DetailCoringPos	0	0	0	0	0	0	0	0	0	0	0	0
DetailCoringNeg	100	100	100	100	100	100	100	100	100	100	0	0
DetailGainLimitPos	2560	2560	2560	2560	2560	2560	2560	2560	2560	2560	0	0
DeatilGainLimitNeg	10240	10240	10240	10240	10240	10240	10240	10240	10240	10240	0	0
DetailExtraStrPos	0	0	0	0	0	0	0	0	0	0	0	0
DetailExtraStrNeg	30	30	30	30	30	30	30	30	30	30	0	0
SlopeLevel	0	0	0	0	0	0	0	0	0	0	0	0
SlopeStrengthLut	Edit Lut	Edit Lut	Edit Lut	Edit Lut	Edit Lut	Edit Lut	Edit Lut	Edit Lut	Edit Lut	Edit Lut	Edit Lut	Edit Lut
DetailLowEn	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☐	☐
DetailGainPosLow	0	0	0	0	0	0	0	0	0	0	0	0
DetailGainNegLow	96	96	96	72	48	0	0	0	0	0	0	0
DetailLimitPosLow	0	0	0	0	0	0	0	0	0	0	0	0
DetailLimitNegLow	10240	10240	10240	10240	10240	10240	10240	10240	10240	10240	0	0
SigmaDisBlur	65535	65535	65535	65535	65535	65535	9000	9000	9000	9000	1	1
SigmaDisPst	1	1	1	1	1	1	1	1	1	1	0	0
SigmaValPst	65535	65535	65535	65535	65535	65535	65535	65535	65535	65535	0	0

Figure 3-112 Automatic parameter configuration table

Tuning Method

1. Select the appropriate Ref Mode.

2. Adjust a set of suitable values under the current illumination/gain and record the Ref Val.

3. Click “Edit Auto Algorithm Table” to open the “Auto Algorithm Table Editor” data table.

4. Add a row to the data table, fill in the Ref Val and parameter sections, then click “OK” to confirm.

5. Click “Export Parameters” to save the modifications in the .h file.“Edit Auto Algorithm Table” Data.

3.13 Demosaic

3.13.1 Introduction

The Demosaic module comprises three sub-modules: Demosaic, FCC, and GIC. The Demosaic submodule interpolates data from the raw domain to the RGB domain, while the FCC and GIC submodules are used to optimize and improve pseudo-colors and grid or maze patterns caused by Demosaic interpolation.

3.13.2 Interface

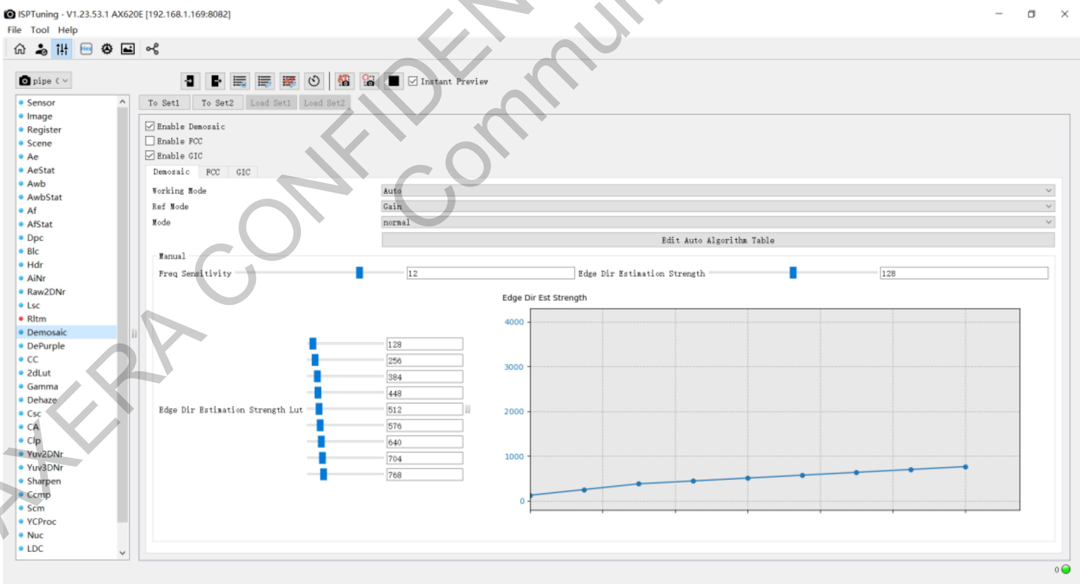


Figure 3-113 Demosaic

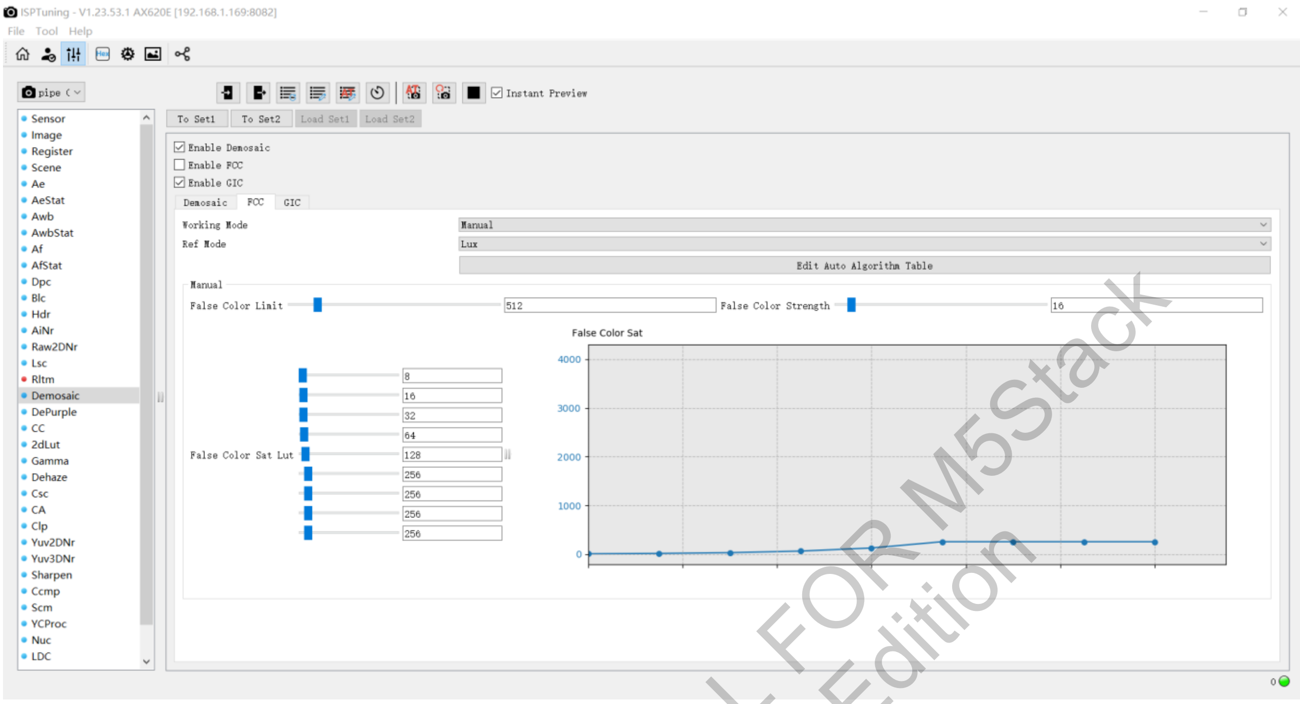


Figure 3-114 Demosaic_FCC

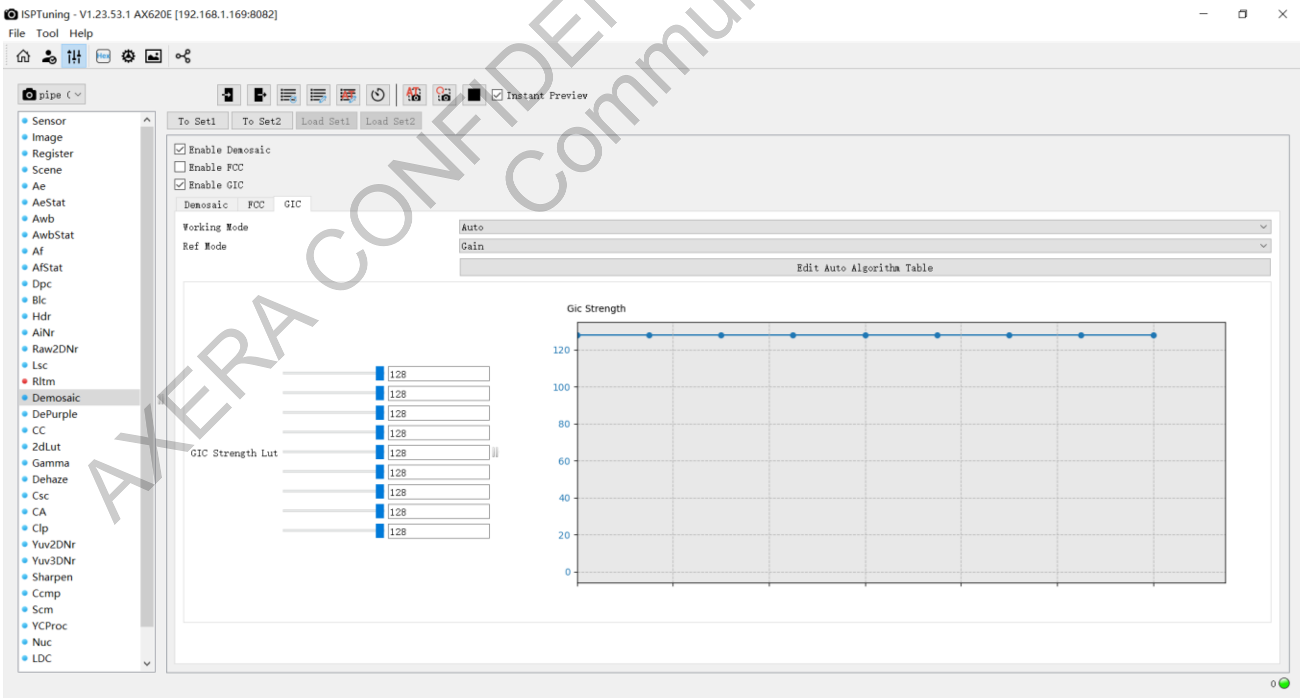


Figure 3-115 Demosaic_GIC

3.13.3 Parameter

Parameter	Description	Range
Enable Demosaic	Demosaic switch.	0, 1
Enable FCC	Toggle switch for the FCC feature	0, 1
Enable GIC	Toggle switch for the GIC feature	0, 1
working mode	Auto/Manual working mode	/
ref mode	Lux/Gain	/
Freq Sensitivity	Intensity of frequency separation	0~16
Edge Dir Estimation Strength	Strength of edge direction estimation. A higher value indicates higher intensity	0~255
Edge Dir Estimation Strength Strength Lut	Sets different detection strengths based on different luminance LUTs. A higher value corresponds to a higher strength. The luminance LUT is divided into 8 parts with 9 points each, ranging from 0 to 255.	0~4095
working mode	Auto/Manual working mode	/
ref mode	Lux/Gain	/
False Color Limit	Limit for false color correction	0~4095
False Color Strength	Strength of false color suppression. A higher value indicates higher suppression intensity.	0~255
False Color Sat Lut	Controls the saturation of false colors based on luminance. A higher value leads to greater saturation suppression. The luminance LUT is divided into 8 parts with 9 points each, ranging from 0 to 255.	0~4095
working mode	Auto/Manual working mode	/
ref mode	Lux/Gain	/

Parameter	Description	Range
GIC Strength Lut	Sets the strength of G-channel imbalance correction based on LUT. A higher value indicates greater correction strength. The luminance LUT is divided into 8 parts with 9 points each, ranging from 0 to 255.	0~128

- Freq Sensitivity: The blending ratio between traditional interpolation methods and biased high-frequency texture interpolation. A smaller value leans towards traditional interpolation, while a larger value leans towards high-frequency texture interpolation.
- Edge dir est strength: The stronger the strength, the weaker the zipper effect, reducing the likelihood of discontinuities, but it may result in some loss of sharpness.

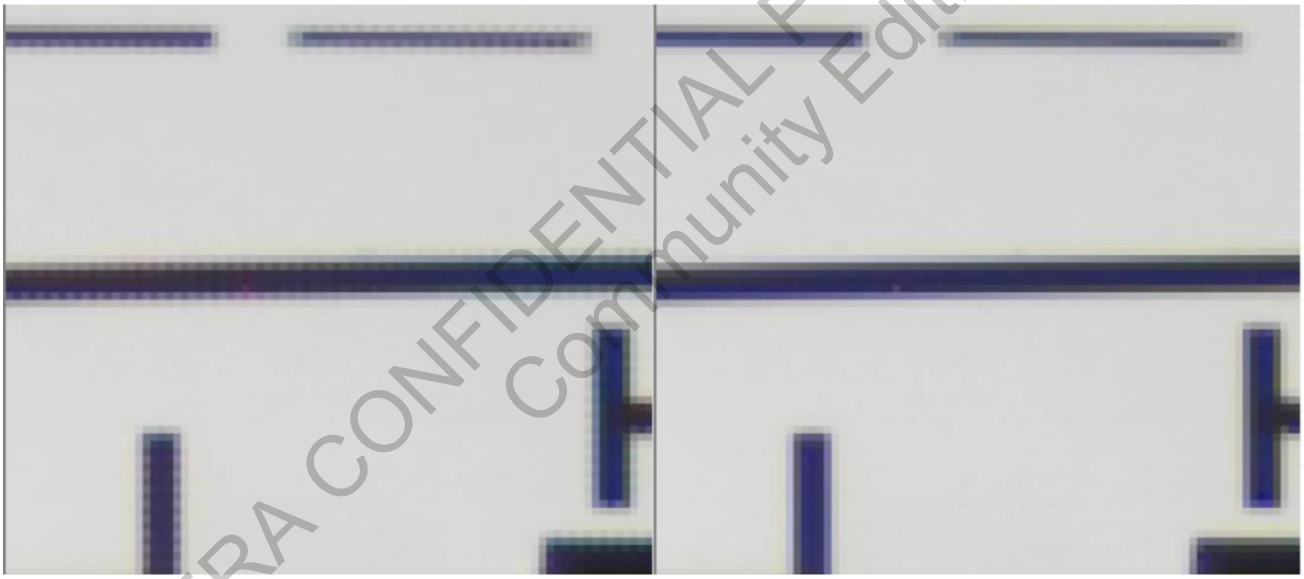


Figure 3-116 Edge dir est strength (0, 255)

- Edge dir est strength Lut: Similar to Edge dir est strength, the stronger the strength, the weaker the zipper effect, reducing the likelihood of discontinuities, but it may result in some loss of sharpness. It works in conjunction with Edge dir est strength.
- False Color Limit: The difference threshold for false color correction. If the difference is smaller than this value, false color correction is applied; otherwise, it is not. The recommended value is 512.

- False Color Strength: The strength of false color correction. A higher value enhances the ability to remove false colors but may affect high-frequency colors.
- False Color Sat Lut: Removes false colors within the saturation range based on different luminance levels.
- Enable GIC: Switch to enable G-channel imbalance correction.
- GIC Strength Lut: A lookup table for G-channel imbalance correction strength coefficients. The X-axis represents luminance, and the Y-axis represents the correction strength coefficient. A higher value indicates stronger correction, but it may also affect sharpness.

3.13.4 Debugging Steps

Step 1

- Adjust the Edge dir est strength and Edge dir est strength lut parameters in the Demosaic module to ensure that strong edges do not exhibit obvious discontinuities or zipper effects.
- Adjust the Freq Sensitivity value to ensure that there are no obvious discontinuities in high-frequency areas.

Step 2

- In the FCC module, set the False Color Limit value to 512 and adjust the False Color Strength and False Color Sat Lut to clean up pseudo colors as much as possible without affecting high-frequency colors.
- Observe whether there are moiré patterns or maze patterns in flat areas of the image. If so, adjust the GIC Strength Lut to eliminate these patterns.

3.13.5 Auto mode

Parameter Description

- Working Mode
  - Description: Switches between auto/manual mode

- Parameter
  - Manual: Manual mode, allows for freely adjusting parameters.
  - Auto: In automatic mode, parameters are adjusted based on gain/luminance as reference values.

➢ Ref Mode

- Selection of reference value type. This value affects the meaning of Ref Val in the Auto Algorithm Table.
- Parameter
  - Ref Mode=0 represents using Lux: In this case, Ref Val in the Auto Algorithm Table actually represents Lux. This parameter changes with the illuminance.
  - Ref Mode=1 represents using Gain: In this case, Ref Val in the Auto Algorithm Table actually represents gain. T This parameter changes with the gain.

☞ When Ref Mode uses Gain, the Gain here is Total Gain (current Again × current Dgain × current ISPGain × LCGHCGRatio).

➢ Ref Val

Displays the current numerical value of Ref Val.

3.14 Depurple

3.14.1 Introduction

A module for removing purple fringing in the raw domain, supporting both purple fringing region detection and correction.

Detection Functionality: Supports PFD feature for identifying purple fringing areas.

Correction Functionality: Receives purple fringing region masks from the PFD output, and performs CLC correction within the masked regions.

3.14.2 Interface

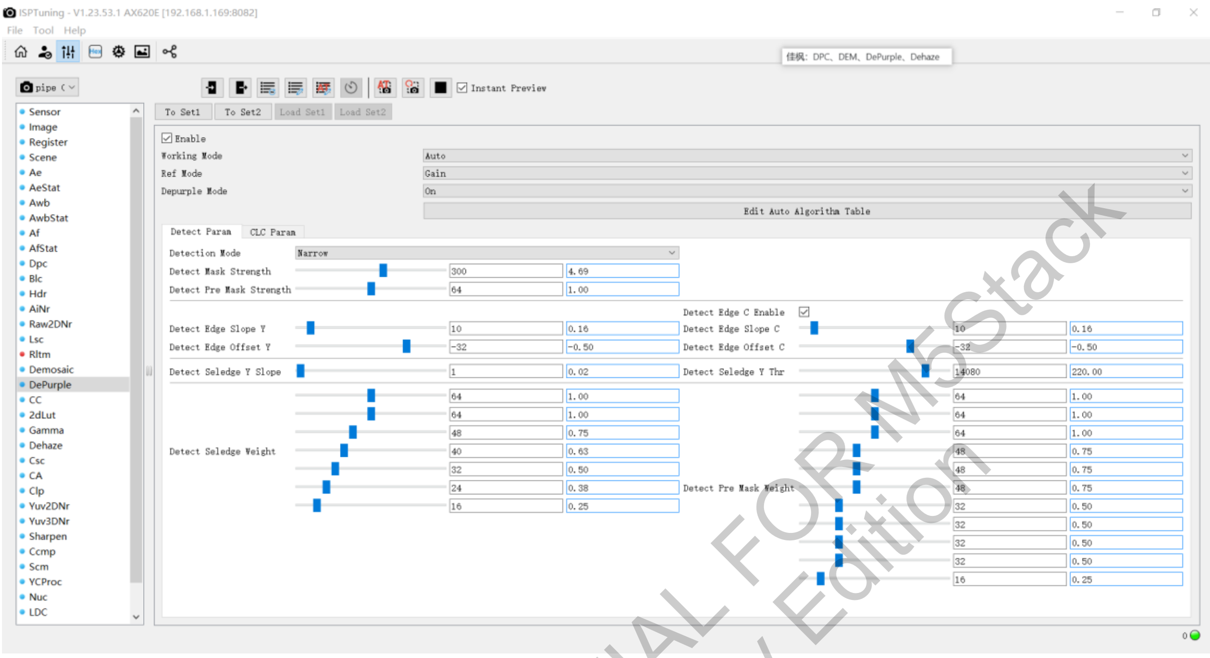


Figure 3-117 Depurple

Figure 3-118 Depurple

3.14.3 Parameter

Parameter	Description	Range
Enable Depurple	Depurple switch	0.1
Working Mode	Manual/Auto	0.1
Ref Mode	LUX/GAIN	0,
Depurple Mode	ON/OFF, effective when Enable Depurple is on	0.1
Edit Auto Algorithm Table	Configure auto parameter table	\
Detection Mode	Normal: Standard width for purple fringing detection	\
	Narrow: Narrower width for purple fringing detection (recommended)	\
Detect Mask Strength	Strength of the current frame mask detection	0~511
Detect Pre Mask Strength	Strength of the previous frame mask detection	0~127
Detect Edge Slope Y	Slope of edge luminance (Y) detection, higher values indicate higher detection strength	0~127
Detect Edge Offset Y	Offset of edge luminance (Y) detection, higher values indicate higher detection strength	-128~0
Detect Edge C Enable	Enable switch for edge color detection	0.1
Detect Edge Slope C	Slope of edge color (UV) detection, higher values indicate higher detection strength	0~127
Detect Edge Offset C	Offset of edge color (UV) detection, higher values indicate higher detection strength	-128~0
Detect Seledge Y Slope	Slope of edge luminance (Y) detection threshold	0~127
Detect Seledge Y Thr	Threshold of edge luminance (Y) detection	0~16383
Detect Seledge Weight	Weight of edge detection for the current frame	0~127
Detect Pre Mask Weight	Weight of edge detection for the previous frame	0~127
Luma Ratio Lut	Weight adjustment based on luminance	0~128
Angle Ratio Lut	Weight adjustment based on hue	0~128
Sat Ratio Lut	Weight adjustment based on saturation	0~128
Compe Strength	Correction fusion strength parameter, higher values indicate stronger correction	0~128
Highlight Mask Enable	Enable switch for highlight mask display	0.1
Highlight Mask Thr	Highlight mask threshold	0~16

3.14.4 Debugging Steps

1) Debugging the Purple Edge Region:

1. Enable Highlight Mask by turning on Highlight Mask Enable and adjusting Highlight Mask Thr to the maximum.
2. Configure Detect Seledge Y Thr to be between 180 and 200.
3. Set Detect Seledge Y Slope to 1.
4. Adjust Detect Edge Offset Y to around -30.
5. Set Detect Edge Slope Y to around 10 (C channel can be set to match Y channel).
6. Fine-tune Detect Mask Strength to ensure that the purple edge area can be detected.

2) Adjusting Luma Ratio Lut, Angle Ratio Lut, and Sat Ratio Lut:

1. Increase the weights for high luminance, hue, and saturation regions where purple edge removal is needed.
2. Ensure that the adjustments result in effective purple edge removal.

Figure 3-119 Depurple Effect

3.14.5 Auto mode

Parameter Description

➢ Working Mode

- Description: Switches between auto/manual mode
- Parameter

- Manual: Manual mode, allows for freely adjusting parameters.
- Auto: In automatic mode, parameters are adjusted based on gain/luminance as reference values.

➢ Ref Mode

- Selection of reference value type. This value affects the meaning of Ref Val in the Auto Algorithm Table.
- Parameter
  - Ref Mode=0 represents using Lux: In this case, Ref Val in the Auto Algorithm Table actually represents Lux. This parameter changes with the illuminance.
  - Ref Mode=1 represents using Gain: In this case, Ref Val in the Auto Algorithm Table actually represents gain. T This parameter changes with the gain.

☞ When Ref Mode uses Gain, the Gain here is Total Gain (current Again × current Dgain × current ISPGain × LCGHCGRatio).

➢ Ref Val

Displays the current numerical value of Ref Val.

3.15 Color Correction

3.15.1 Introduction

Color Correction is a color adjustment module that offers both traditional color correction methods using CCM matrices and separate adjustment functions based on 16 hue angles.

➢ It supports color transformation, where each color can be configured using a color matrix with 360/16-degree options.

➢ Low-power mode is available, which does not utilize color matrix interpolation.

➢ It can take input for purple fringe correction from NPU/PFD masks.

➢ NPU/PFD mask size scaling is supported.

➢ It offers purple fringe correction area display for IQ tuning.

➢ The module can use mask level, luma, hue, and saturation configurations to adjust NPU/PFD mask effects.

3.15.2 Interface

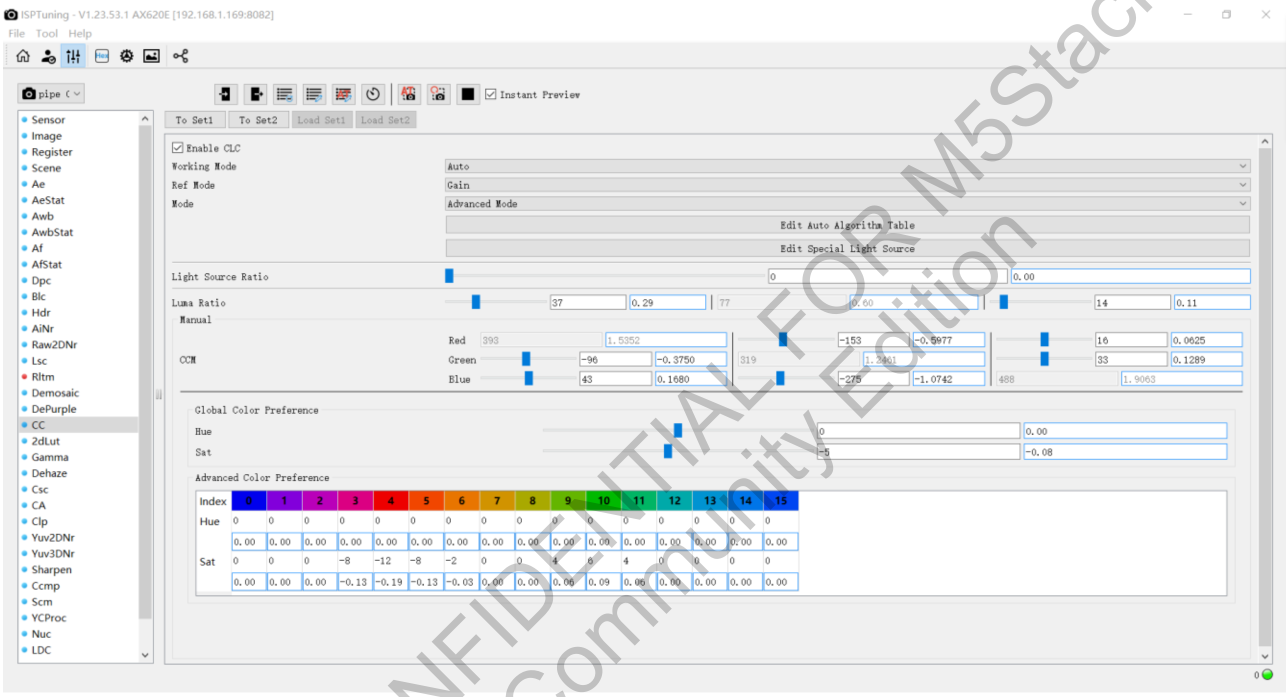


Figure 3-120 Color Correction

3.15.3 Parameter

Parameter	Description	Range
Enable CLC	Enable CC	0 1
Working Mode	Manual/Auto	/
Ref Mode	Gain/Lux	/
Mode	Basic Mode/Advanced Mode	/
Edit Auto Algorithm Table	Automatic clgorithm configuration table	/

Parameter	Description	Range
Edit Special Light Source	Configuration of special light sources	/
Light Source Ratio	Light source ratio	0~256
Luma Ratio	Luma Ratio[0]	0~128
	Luma Ratio[1]	0~128
Hue	Global hue adjustment parameter	-1920 -1920
Sat	Global saturation adjustment parameter	-61 ~ 64

➢ Mode: Color calibration working mode.

■ Basic Mode: The basic mode utilizes a general matrix correction method, offering a relatively simple debugging process. It is suitable for most color restoration scenarios or applications.

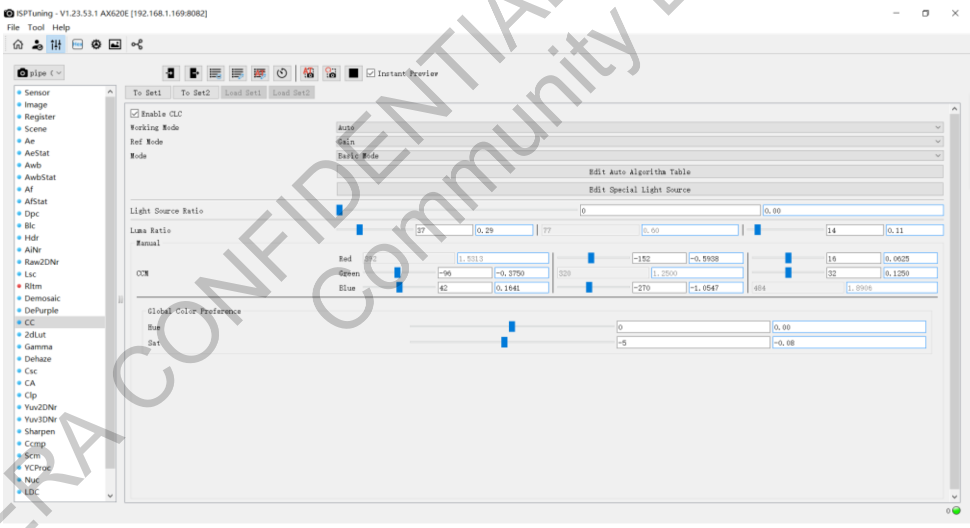


Figure 3-121 Color CorrectionBaseMode

■ Advanced Mode: The advanced mode provides finer control over local color aspects such as hue and saturation based on different angles. The debugging process is relatively complex and is suitable for scenarios or applications with higher color restoration requirements.

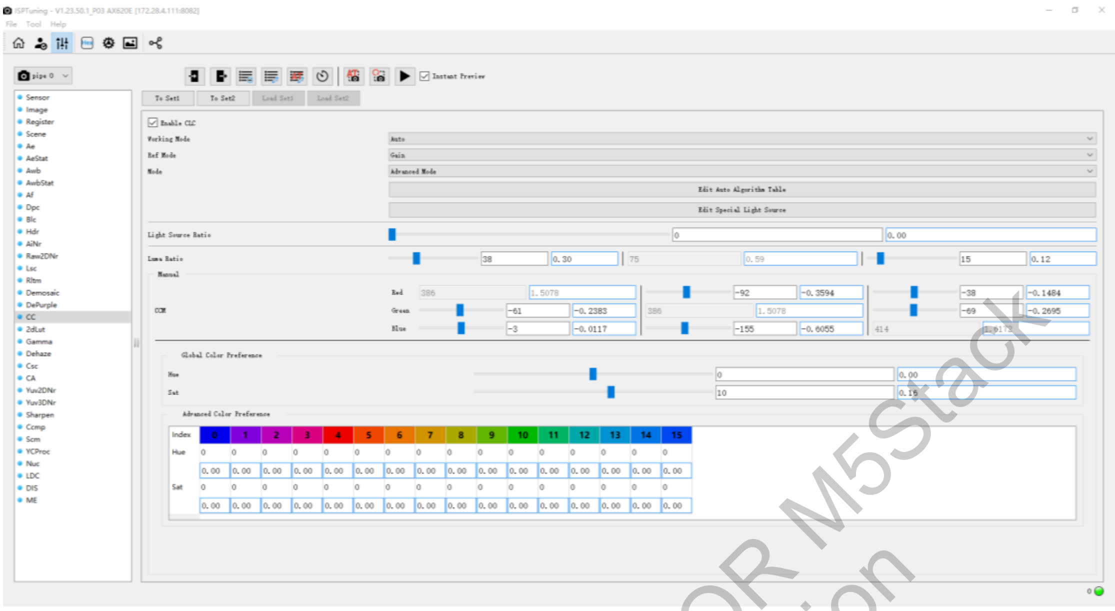


Figure 3-122 Color Correction Advanced Mode

- Light Source Ratio:
  - 0.0: auto_mode0(color temp, lux/gain);
  - 1.0: auto_mode1(light source);
  - 0~1.0: blending with automode0 and automode1;
- Luma Ratio: A parameter affecting the calculation of hue and saturation in both basic and advanced color adjustment settings. The default value is [0.3, 0.59, 0.11], with a range from 0.00 to 1.00. It is generally not recommended to adjust this parameter under normal circumstances.

3.15.4 Auto mode

Parameter Description

- Working Mode
  - Description: Switches between auto/manual mode
  - Parameter
    - Manual: In manual mode, parameters can be freely adjusted.

    - Auto: In automatic mode, parameters are adjusted based on gain/luminance as reference values.

- Ref Mode
  - Choice of reference value type for the automatic strategy, which affects the meaning of Ref Val in the Auto Algorithm Table.
  - Parameter
    - Lux: In this mode, Ref Val in the Auto Algorithm Table is actually the Lux value. This parameter changes with the illuminance.
    - Gain: In this mode, Ref Val in the Auto Algorithm Table is actually the gain. This parameter changes with the gain.
- Ref Val
  - Displays the current numerical value of Ref Val.
- Auto Algorithm Table:
  - Grouped according to CCT into several sets. Each set can be further divided into subgroups based on RefVal, and the ColorPreference and CCM matrix for each subgroup can be set individually.

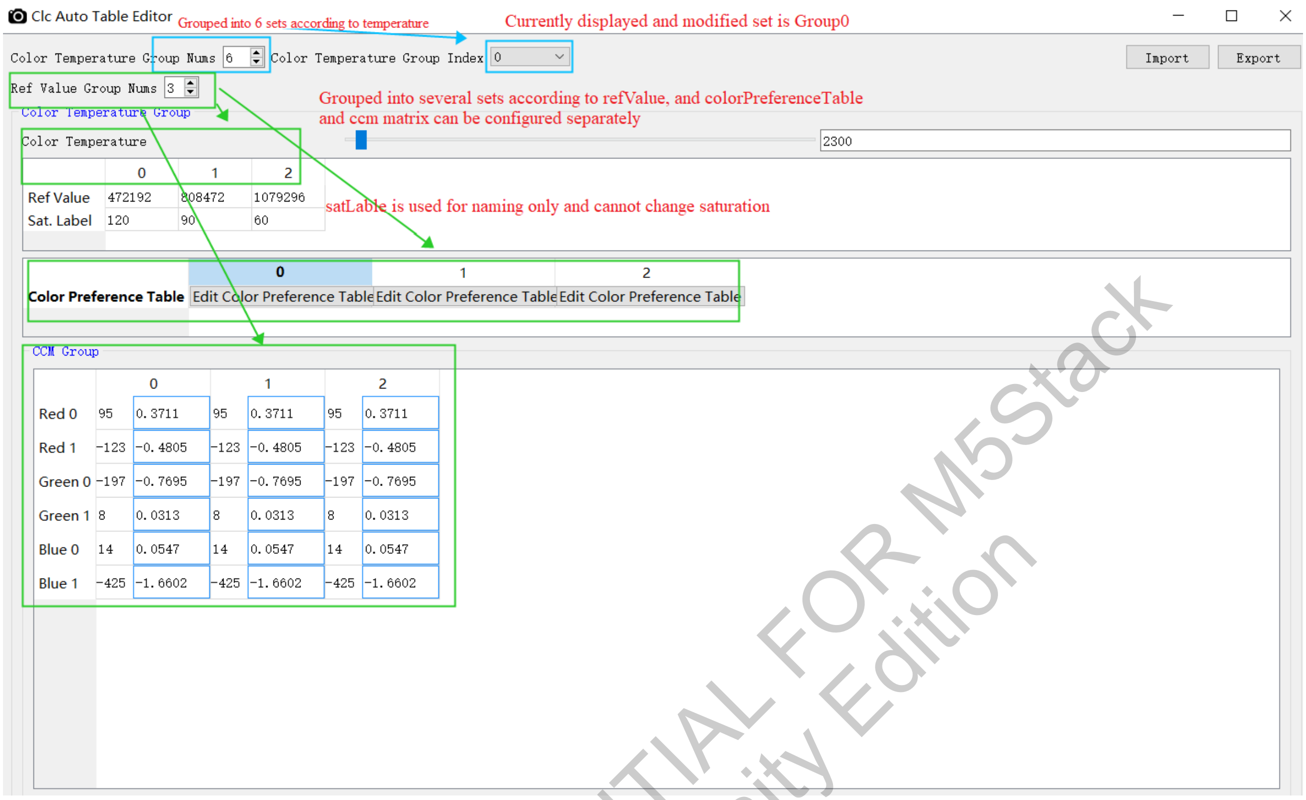


Figure 3-123 Clc Auto Table

➢ Special Light Source:

■ Up to 12 sets of special light sources can be added, supporting the configuration of corresponding Sat, Hue, and CCM matrix for each light source group.

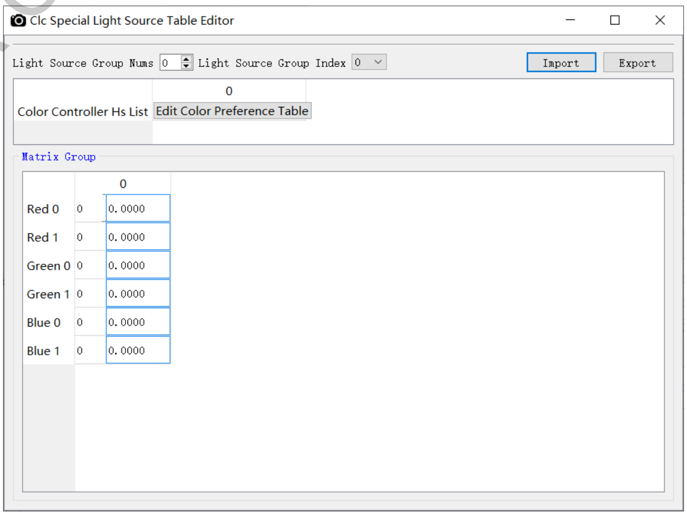


Figure 3-124 Clc Special Light Source Table

3.16 2dLut

3.16.1 Introduction

2dLUT is a module used to correct color effects or color preferences.

3.16.2 Homepage

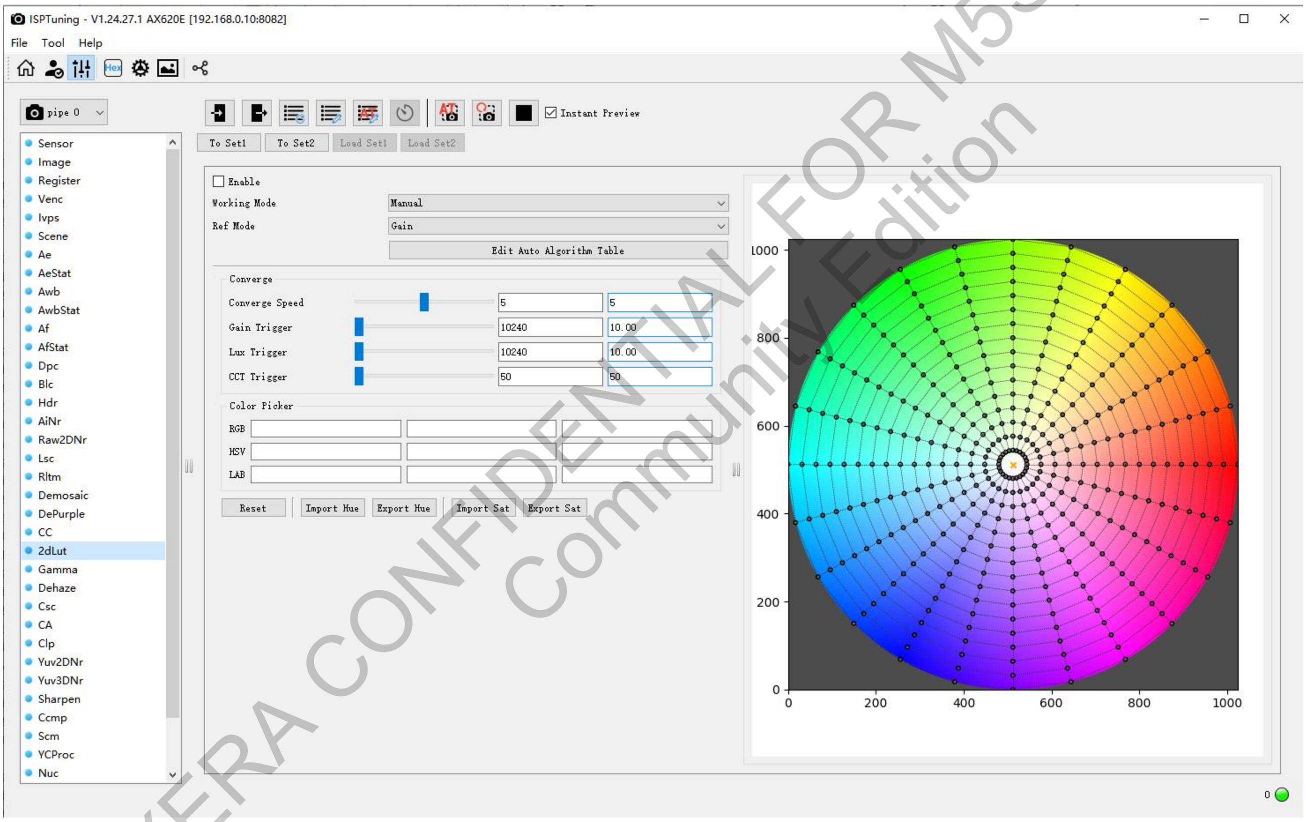


Figure 3-125 2dLut

3.16.3 Parameter Description

In the Manual interface, you can adjust the corresponding hue and saturation by dragging points on the color palette on the right side. In the color palette, different angles represent different colors.

Extending from the center of the circle outward, the saturation increases from low to high. The Hue/Sat

Lut supports import, export, and reset operations.

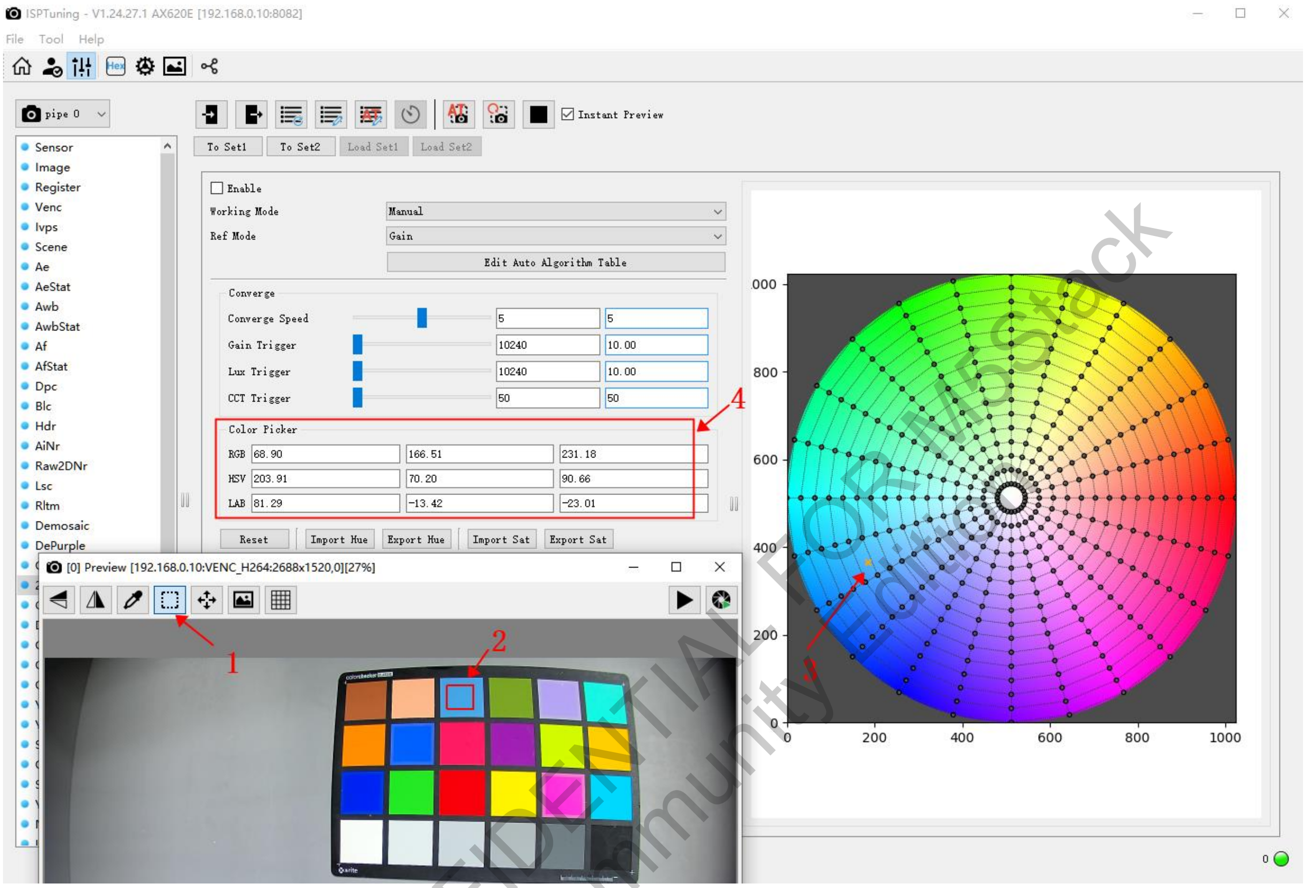


Figure 3-126 Color Picker Demo

Parameter	Description	Range
Enable	Enable	\
Working Mode	Manual/Auto	\
Ref Mode	Lux/Gain	\
Edit Auto Algorithm Table	Configure auto parameter table	\

Converge Speed	Unit: Number of frames. If the number of frames less than the convergence threshold is greater than the converge speed, then convergence is considered complete.	0~10
Gain Trigger	Gain threshold: triggers convergence when the gain difference between successive frames exceeds this threshold.	
Lux Trigger	Lux threshold: triggers convergence when the lux difference between successive frames exceeds this threshold.	
CCT Trigger	CCT threshold: triggers convergence when the CCT difference between successive frames exceeds this threshold.	
RGB	Not adjustable, displays the RGB values of the selected area.	\
HSV	Not adjustable, displays the HSV values of the selected area.	\
LAB	Not adjustable, displays the LAB values of the selected area.	\

3.16.4 Auto mode

The automatic mode for 2D LUT is divided into two levels of triggers:

- First, based on Lux/Gain refVal, it can be divided into up to 12 groups.
- Within each group, it can be further divided into up to 16 sub-groups based on CCT, with each

sub-group having its own Hue Table and Sat Table set individually.

- Linear interpolation is performed between groups.

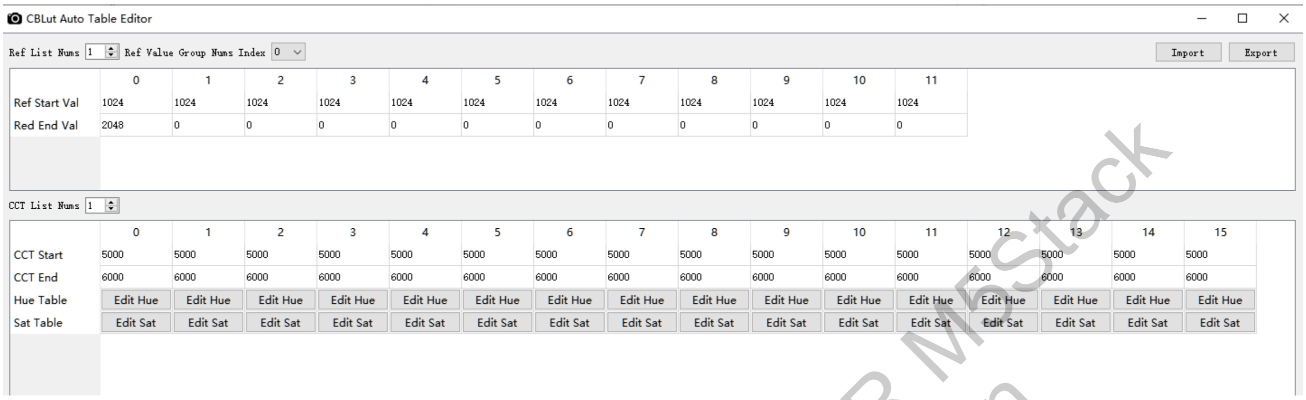


Figure 3-127 CBLut Auto Table

3.17 Gamma

3.17.1 Introduction

The gamma curve is a type of tone curve. When the gamma value is equal to 1, the curve forms a straight line at a 45° angle to the coordinate axis, indicating that the input and output luminance are the same. Gamma values higher than 1 will increase the output luminance, while gamma values lower than 1 will decrease the output luminance.

The Gamma module maps the RGB channels separately in the Linear RGB domain, transforming the image into the sRGB domain. In the gamma mapping process, all three RGB channels share the same mapping curve.

3.17.2 Interface

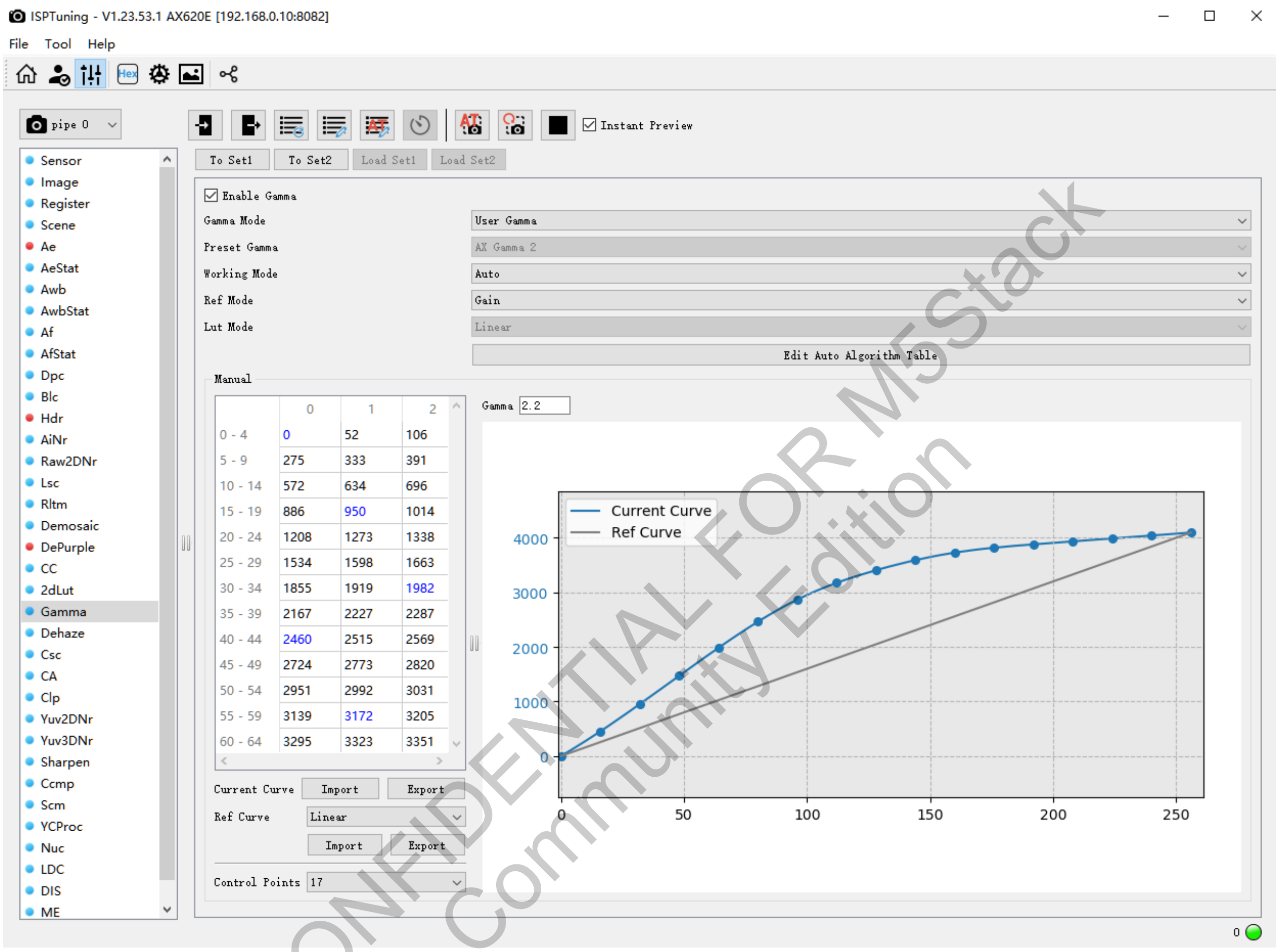


Figure 3-128 Gamma

3.17.3 Parameter

Parameter		Description
Gamma Mode	User Gamma	Customized Gamma
	Preset Gamma	Preset Gamma refers to a set of predefined gamma curves that you can choose from. There are typically seven options available for selection. SDR gamma2 and HDR gamma1 are often recommended choices.
Work Mode	Manual/Auto	Manual/Automatic mode
Ref Mode	Gain/Lux	Gain/Lux as reference values

Lut Mode	Linear	The spacing between the sampling points on the X-axis of the gamma curve remains uniform
	Exponential	The spacing between the sampling points on the X-axis of the gamma curve increases exponentially
Edit Auto Algorithm Table	Allows editing of the automatic parameter configuration table	

- The Gamma parameter allows for custom gamma mapping, where the output values are typically in the u8 range. The gamma value corresponds to the shape of the gamma curve.

$$y = x^{\frac{1}{gamma\ \ value}}$$

For example, a gamma value of 2.2 corresponds to a specific curve shape: $y = x^{\frac{1}{2.2}}$

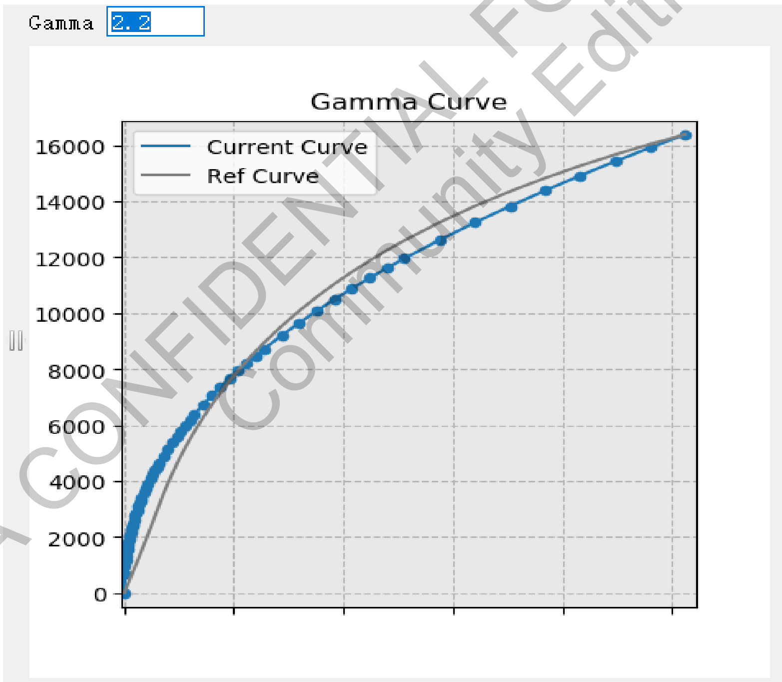


Figure 3-129 Gamma Curve

- Allows you manually modify the gamma table point by point.
- The Current Curve feature enables you to import and export the current gamma settings.
- RefCurve: Provides preset reference gamma curves, displayed in gray on the coordinate graph on the right side, and supports exporting.

3.17.4 Auto mode

- Working Mode
  - Description: Switches between auto/manual mode
  - Parameter
    - Manual: In manual mode, parameters can be freely adjusted.
    - Auto: In automatic mode, parameters based on gain/luminance Lux serve as reference value Ref Val to select appropriate parameters.
- Ref Mode
  - For automatic mode, parameters based on gain/luminance Lux serve as reference value Ref Val to select appropriate parameters. Mode 0 is Lux, and mode 1 is Gain.
- Auto Algorithm Table
  - Can set three groups of gamma according to refVal

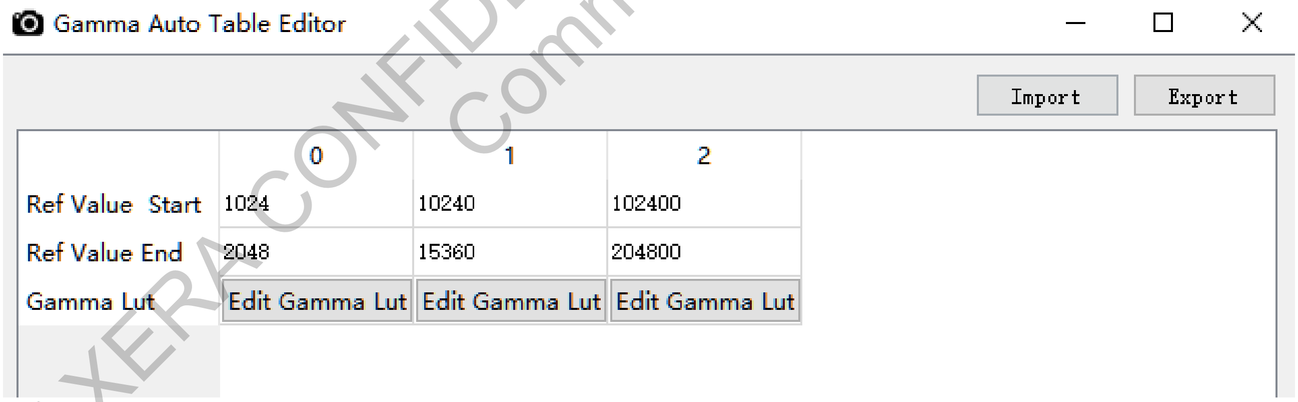


Figure 3-130 Gamma AutoTable

3.18 Dehaze

3.18.1 Introduction

The Dehaze module is primarily designed for haze removal in scenes affected by fog or haze. It helps adjust the contrast and clarity of the image by reducing the haze, thereby enhancing visibility and improving overall image quality.

3.18.2 Interface

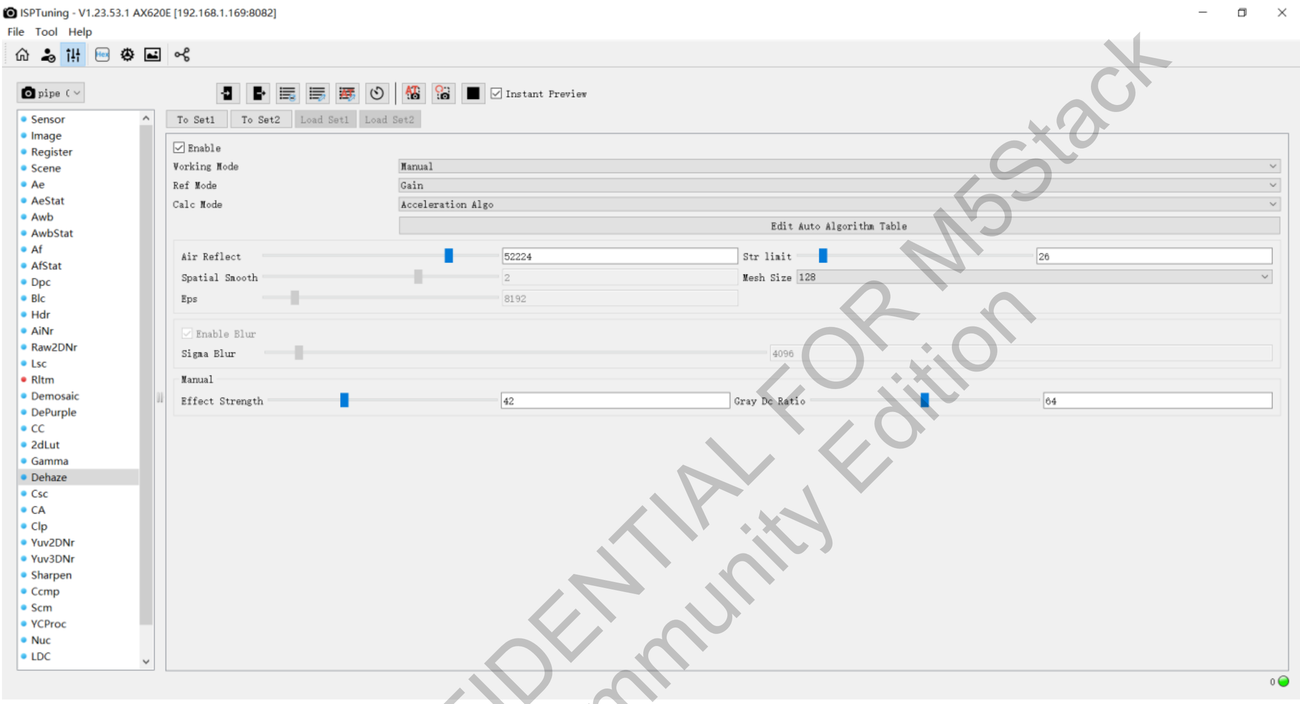


Figure 3-131 Dehaze

3.18.3 Parameter

Parameter	Description	Range
Enable	Module switch, check to turn on	0.1
Working Mode	Choose between manual and automatic modes	0.1
Ref Mode	Select whether to use gain or lux for interpolation	0.1
Calc Mode	Choose between normal mode (traditional Algo) and accelerated mode (accelerational Algo) for dehazing	0.1
Air Reflect	Parameter for estimating atmospheric concentration. A higher value detects denser haze, resulting in stronger dehazing	0~65280
Str Limit	Dehazing strength limit. Used in conjunction with Air	1~256

Parameter	Description	Range
	Reflect, where a higher Str Limit imposes a stronger limit on dehazing strength, while a lower value imposes a weaker limit	
Spatial Smooth	Strength of contrast smoothing after haze removal	0~3
Mesh size	Size of the statistical mesh used for calculations	16,32,64,128
Eps	Generally left unadjusted, 8192 by default	1~65535
Enable Blur	Enable motion compensation for regions affected by motion	0.1
Sigma Blur	Strength of blur applied to motion regions, improving the appearance of motion halos	1~65535
Effect Strength	Dehazing strength value	0~128
Gary DC Ratio	Recommended default value is 64	0~128

3.18.4 Debugging Method

If the CPU loading is high, it is advisable to use the accelerated mode. In this case, adjust the following parameters: Air Reflect, Str Limit, Effect Strength, and Gary DC Ratio. Air Reflect can be set to around 90% of its maximum value. Str Limit adjustment primarily involves observing the highlights; if they appear too bright, increase the intensity, and vice versa. Effect Strength is used to adjust the dehazing strength, where larger values result in stronger dehazing. Keep Gary DC Ratio at its default value.

If using the traditional mode, set the mesh size to 32 for optimal dehazing performance. If halos appear, reduce Spatial Smooth. If there are moving objects causing significant changes in the dehazing effect, enable Blur and increase Sigma Blur to reduce the image changes caused by motion.

3.19 Csc

3.19.1 Introduction

Color Space Convert, a module for converting from the RGB domain to the YUV domain; CSC matrix parameter debugging. This module processes before Ycrt and handles luminance and chroma ranges, recommended to be processed in the YCRT module.

3.19.2 Interface

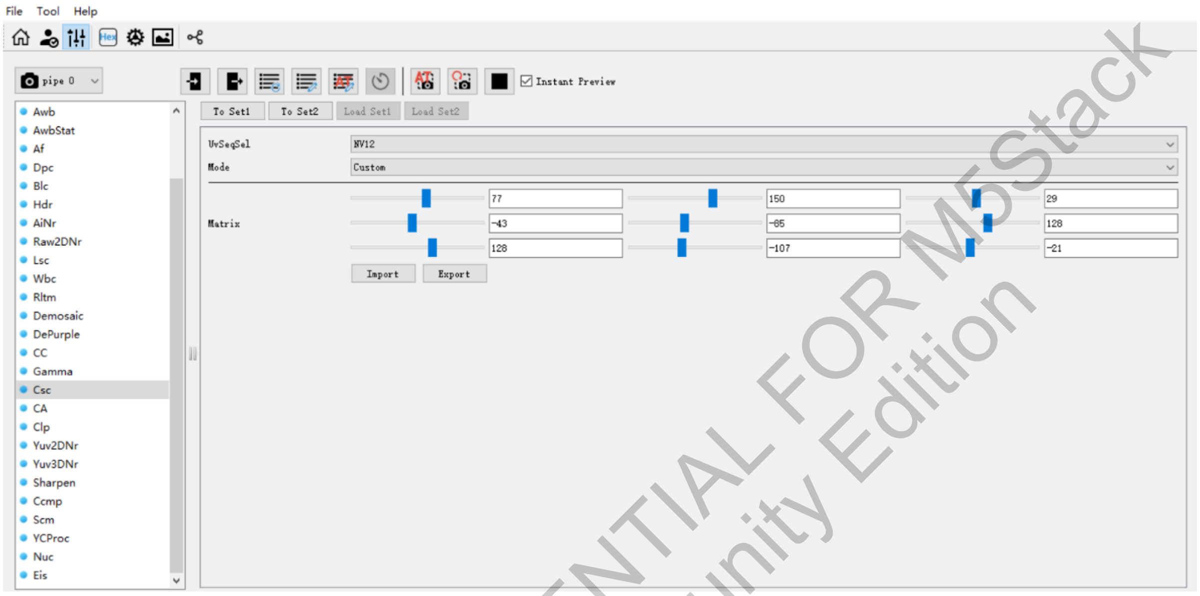


Figure 3-132 CSC

3.19.3 Parameter

Parameter		Description
UvSeqSel	NV12/NV21	YUV storing format
Mode	Custom	User-defined
	BT601	Convert RGB to YUV according to the BT601 standard
	BT709	Convert RGB to YUV according to the BT709 standard
	BT2020	Convert RGB to YUV according to the BT2020 standard

3.20 Color Adjust

3.20.1 Introduction

This module is used for color adjustment in the YUV domain; it allows for the adjustment of preferred colors through saturation and hue modification.

3.20.2 Interface

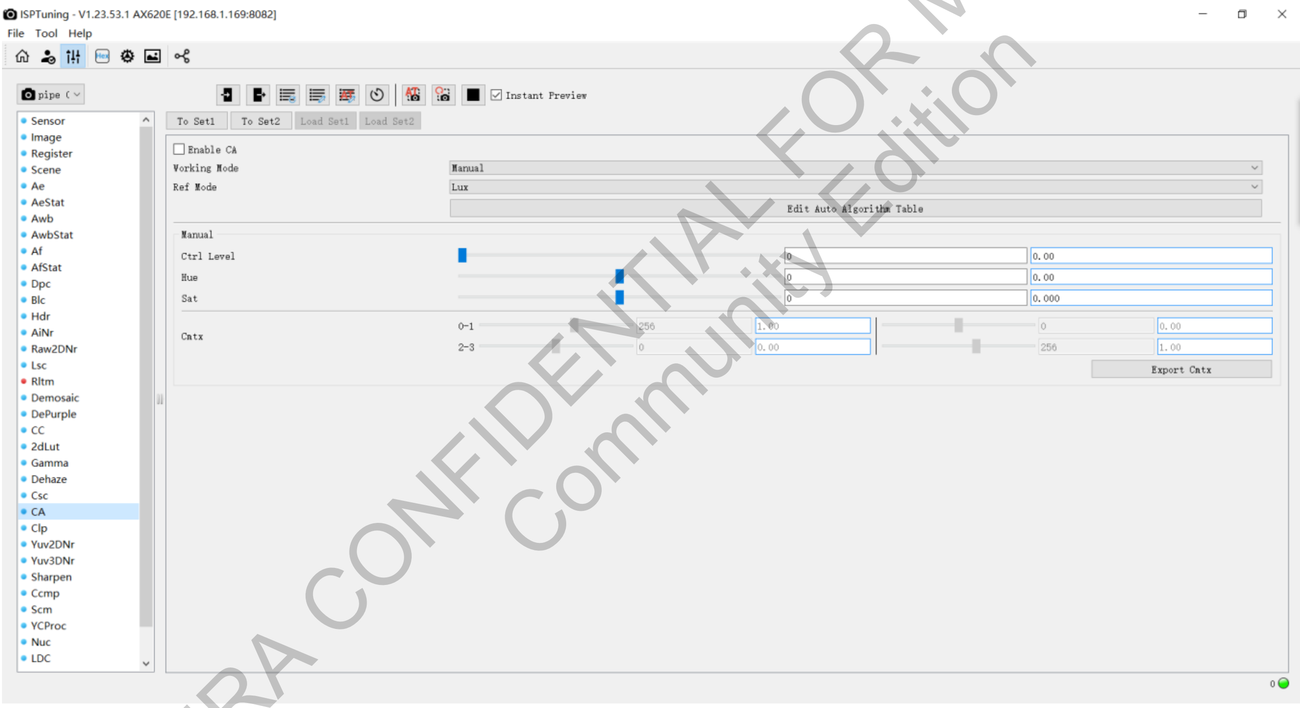


Figure 3-133 ColorAdjust

3.20.3 Parameter

Parameter	Description	Range
Enable CA	Enable CA	0 1
Working Mode	Manual/Auto	/
Ref Mode	Gain/Lux	/

Parameter	Description	Range
Edit Auto Algorithm Table	Automatic clgorithm configuration table	/
Ctrl Level	Adjust the intensity level of color; the higher the value, the greater the color impact. A value of 0 turns off the adjustment, generating a cmtx through hue and saturation adjustments, where the cmtx defaults to the identity matrix. A value of 256 represents the maximum variation in the cmtx matrix when adjusting hue and saturation.	0~256
Hue	Hue shift	-480~480
Sat	Saturation adjustment, the higher the value, the greater the saturation; conversely, the lower the value, the less the saturation.	-800~800
Cmtx	The color matrix generated for adjusting hue and saturation.	/

Debugging Suggestions: When the cmtx is an identity matrix, the CA module does not adjust the color. This module can significantly affect the overall color of the image, so parameter adjustments should be made cautiously.

3.21 Yuv3DNr

3.21.1 Introduction

Yuv3DNr performs spatio-temporal denoising in the YUV domain, using motion or still region luminance and chrominance noise reduction based on motion masks generated by motion detection or external masks. If LCE (including Sharpen) is placed before Y3DNR, the processing flowchart of Yuv3Dnr is as shown in the figure below.

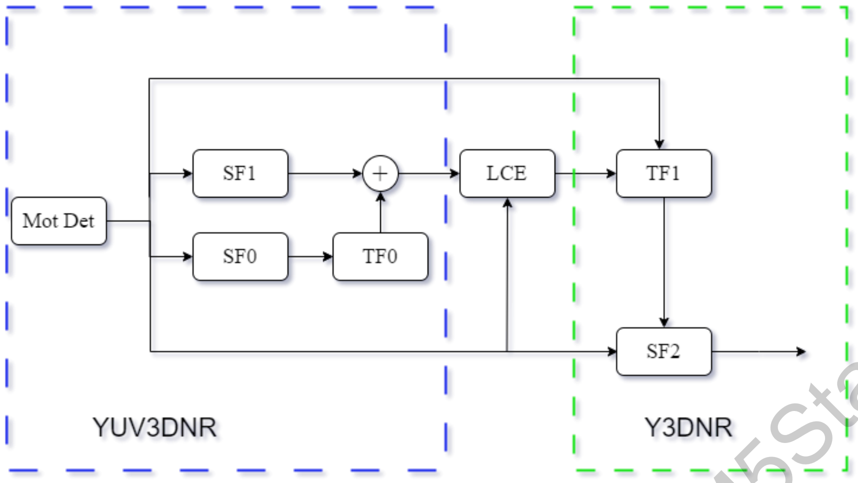


Figure 3-134 Yuv3Dnr Handling Process

Above is the Yuv3Dnr denoising process.

1. SF0: Suitable for low-frequency noise reduction.

2. SF1: Suitable for high-frequency noise reduction.

3. TF0: Perform temporal filtering on the SF0 result using the reference frame.

4. Combination: Upsample the SF0 result, add it to the SF1 result, and send it to LCE for sharpening. After sharpening, continue to perform TF1 using the reference frame.

5. SF2: Perform final denoising and output.

! Note: The LCE module mainly includes the following components: Yuv2dnr, Sharpen, 2dLut, CCMP, and Clp modules.

3.21.2 Interface

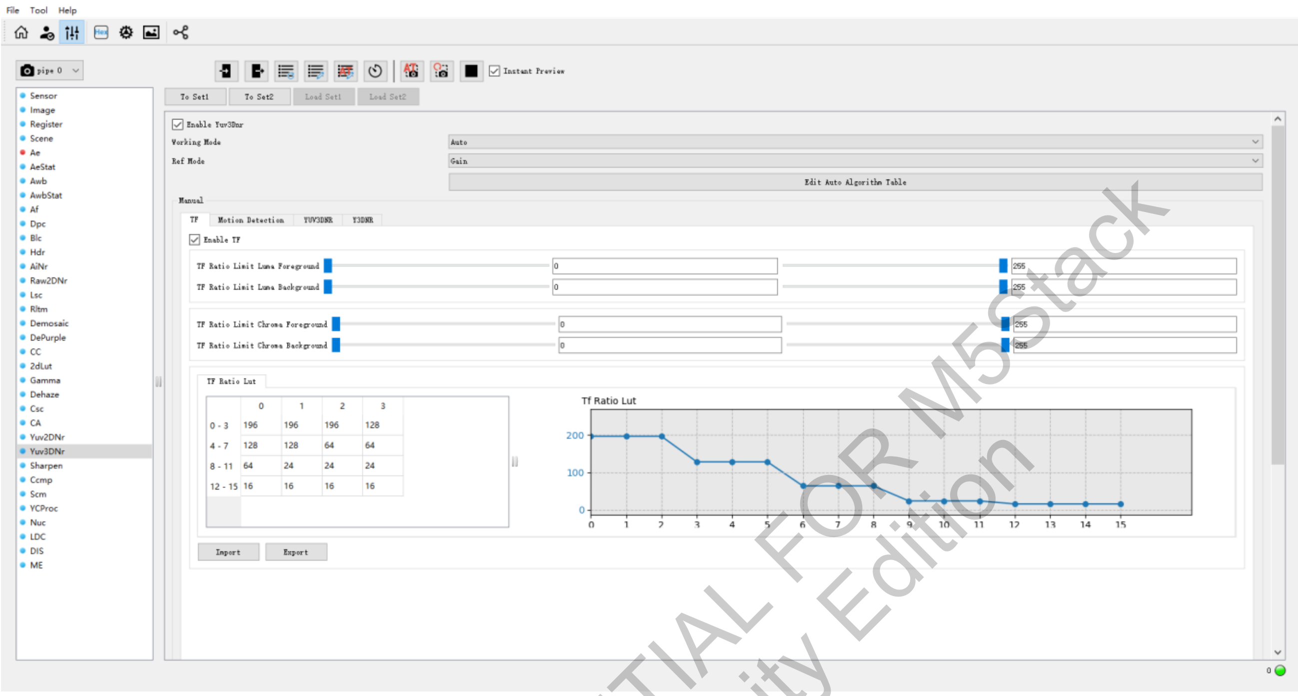


Figure 3-135 Yuv3Dnr_TF

3.21.3 Parameter

1. TF Parameter Description

Parameter	Description	Range
Working Mode	Manual/Auto	/
Ref Mode	This value determines the basis for Ref Val in the Auto Algorithm Table.□ When Ref Val is Lux, current parameters change with illuminance.□ When Ref Val is gain, current parameters change with gain.	/
Edit Auto Algorithm Table	Allows editing of the automatic parameter configuration table	/
Enable TF	Temporal denoising enable switch	0, 1
	TF Ratio Limit Luma Foreground[0] [1]	0~255

TF Ratio Limit Luma Foreground	Temporal ratio limit for foreground luminance	Affects the TFRatio calculation result for the foreground, impacting the temporal intensity for the foreground.	0~255
TF Ratio Limit Luma Background	Temporal ratio limit for background luminance	TF Ratio Limit Luma Background[0] [1]	0~255
		Affects the TFRatio calculation result for the background, impacting the temporal intensity for the background.	0~255
TF Ratio Lut	Represents the mixing ratio between the current frame and the reference frame. A larger value indicates more mixing of the current frame, resulting in weaker temporal denoising. The horizontal axis represents the accumulated calculation value of the current frame status. A larger value indicates a higher likelihood of being a still region.		0~255

2. Motion Detection Parameter Description

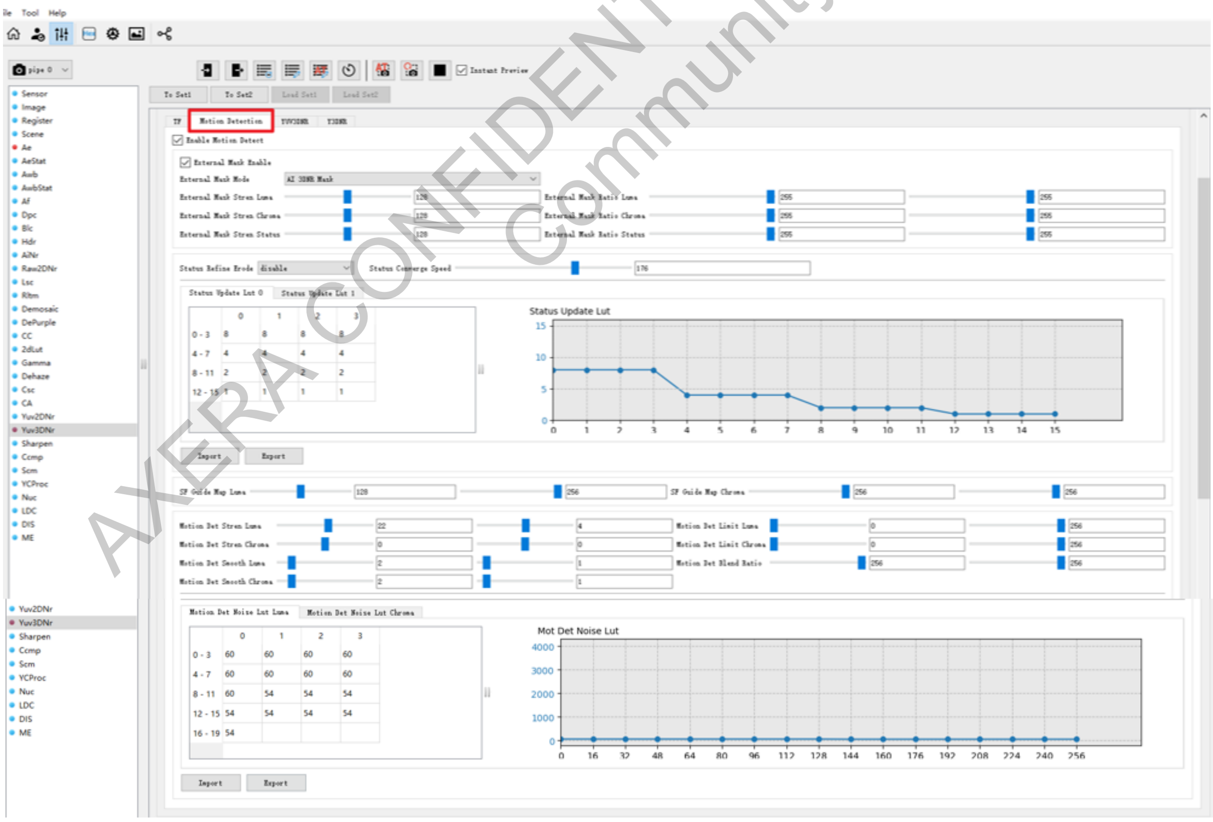


Figure 3-136 Yuv3Dnr_ Motion Detection

Motion Detection			
Enable Motion Detect	Motion detection switch		0 1
External Mask Enable	External mask switch		0 1
External Mask Mode	AI 3DNR Mask/ HDR Mask		/
External Mask Stren Luma	External Y-domain motion mask strength		0~255
External Mask Ratio Luma	External Mask Ratio Luma[0][1]	The fusion ratio between the external Y-domain motion mask and the YUV3D motion mask. A larger value indicates a higher proportion of the External Mask.	0~256
External Mask Stren Chroma	External UV-domain motion mask strength		0~255
External Mask Ratio Chroma	External Mask Ratio Chroma[0][1]	The fusion ratio between the external UV-domain motion mask and the YUV3D motion mask. A larger value indicates a higher proportion of the External Mask.	0~256
External Mask Stren Status	External mask status strength		0~255
External Mask Stren Status	External Mask Ratio Status[0] [1]	The fusion ratio between the external motion mask and the YUV3D motion mask. A larger value indicates a higher proportion of the External Mask.	0~256
Status Refine Erode	disable	Disable erosion based on the status results of the previous frame.	/
	erode 3x3	Perform a 3x3 erosion based on the status results of the previous frame to expand the motion mask outward.	/
	erode 5x5	Perform a 5x5 erosion based on the status results of the previous frame to expand the motion mask outward.	/
Status Converge Speed	Controls the convergence speed of the transition area between the current frame and the previous frame's status.		0~255
Status Update Lut 0	A control table for the score counter of the current pixel status in motion detection. When the current pixel is determined to be in a stationary state, it gets a score, with a		0~15

	maximum score of 15 indicating a completely stationary state, where temporal effects are the strongest. This is used to determine the confidence level of the current pixel being in a motion state over consecutive frames. The larger the score result, the more likely it is to be stationary, with a maximum of 16 frames. When the current frame is determined to be stationary, the status cumulative value increases by the corresponding value on the vertical axis. The horizontal axis represents the current status cumulative value.		
Status Update Lut 1	A control table for the score counter of the current pixel status in motion detection. When the current pixel is determined to be in motion, it gets a penalty, subtracting the value set in the table. This is used to look up the Status Update Lut 0 for further counting based on the pixel's status value. When the current frame is determined to be in motion, the status cumulative value decreases by the corresponding value on the vertical axis. The horizontal axis represents the current status cumulative value.		0~15
SF Guide Map Luma	SF Guide Map Luma[0][1]	The mixing ratio of the current frame's MotionMask and the previous frame's Status in the Y domain. Example: ➢ [256,256]: Use only the previous frame's status. ➢ [0,0]: Use only the current frame's motion mask. ➢ Setting other values will mix the two. Adjusting this parameter can be done using: echo 2 > /tmp/yuv3dnr_debug_mode_0. In debug mode, this shows the state of the spatial denoising effect range of the current image. Increasing or decreasing this value will affect the effective range of spatial denoising.	0~256
SF Guide Map Chroma	SF Guide Map Chroma[0][1]	The mixing ratio of the current frame's MotionMask and the	0~256

		previous frame's Status in the UV domain. Its function is the same with that of Y-domain Guide Map.	
Motion Det Stren Luma	Motion Det Stren Luma[0]	The strength of motion detection for the foreground in the Y domain. The larger the value, the more pixels in the foreground are detected as motion. ➢ Note: The distinction between foreground and background is based on the status scoring results, with a value of 0 indicating pure motion and a value of 16 indicating pure stillness.	0~255
	Motion Det Stren Luma[1]	The strength of motion detection for the background in the Y domain. The larger the value, the more pixels in the background are detected as motion. ➢ Typically, the value of Motion Det Stren Luma[0] is set higher, and the value of Motion Det Stren Luma[1] is set lower. This ensures that foreground motion is detected while preventing large raindrop noise in the background. ➢ Adjusting this parameter can be done using: echo 1 > /tmp/yuv3dnr_debug_mode_0. In debug mode, this shows the current state of the motion mask for the image. Increasing or decreasing this value will affect the effectiveness of the motion mask.	0~255

Motion Det Limit Luma	Motion Det Limit Luma[0][1]	The limit range for motion detection results in the Y domain is recommended to be set from 0 to 256. ➢ To allow some temporal noise in the stationary region with high gain, you can increase Motion Det Limit Luma[0]. Increasing limit[0] raises the minimum motion intensity, making it easier to classify background noise as a motion area, thereby reducing the temporal intensity of the background.	0~256
Motion Det Stren Chroma	Motion Det Stren Chroma[0]	The strength of motion detection for the foreground in the UV domain. The larger the value, the more pixels in the foreground are detected as motion. The usage is the same with that of Motion Det Stren Luma.	-255~255
	Motion Det Stren Chroma[1]	The strength of motion detection for the background in the UV domain. The larger the value, the more pixels in the background are detected as motion. The usage is the same with that of Motion Det Stren Luma.	-255~255
Motion Det Limit Chroma	Motion Det Limit Chroma[0] [1]	The limit range for motion detection results in the UV domain is recommended to be set from 0 to 256.	0~256
Motion Det Blend Ratio	Motion Det Blend Ratio[0][1]	The fusion ratio of the motion detection results between the Y and UV domains. ➢ Examples: [0, 0]: Use only the UV channel's mask. [256, 256]: Use only the Y channel's mask.	0~256

		➢ Setting other values will blend the masks from both the Y and UV channels. ➢ It is recommended to use the motion detection mask of the Y channel.	
Motion Det Smooth Luma	Motion Det Smooth Luma[0][1]	The amplification factor for the motion mask of the foreground/background in the Y channel.	
Motion Det Smooth Chroma	Motion Det Smooth Chroma[0][1]	The amplification factor for the motion mask of the foreground/background in the UV channel.	
Motion Det Noise Lut 0	The motion detection curve for the Y domain, where the horizontal axis represents luminance and the vertical axis represents the motion detection noise intensity. The larger the value on the vertical axis, the more likely it is for the corresponding luminance to be detected as noise, resulting in stronger temporal filtering.		0~4095
Motion Det Noise Lut 1	The motion detection curve for the UV domain, where the horizontal axis represents luminance and the vertical axis represents the motion detection noise intensity. The larger the value on the vertical axis, the more likely it is for the corresponding luminance to be detected as noise, resulting in stronger temporal filtering.		0~4095

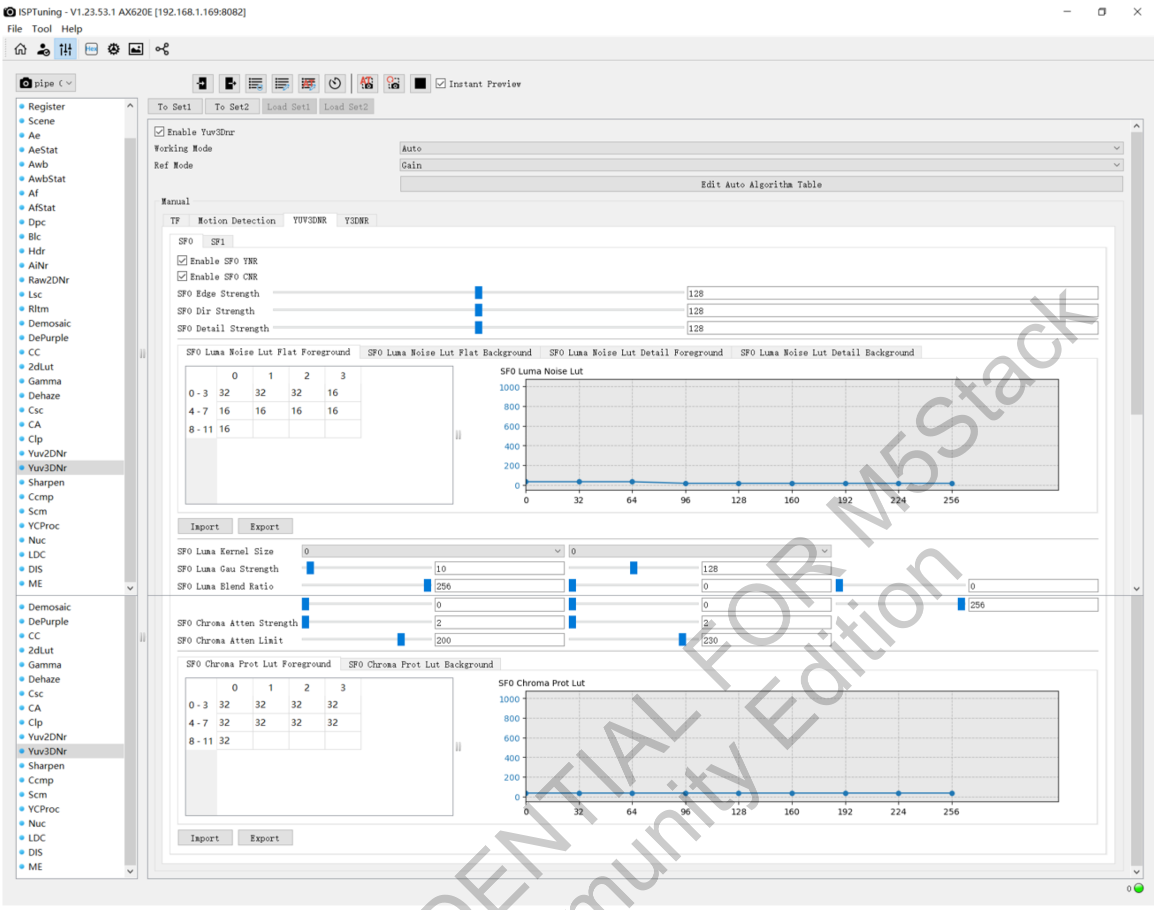


Figure 3-137 Yuv3Dnr_ SF0

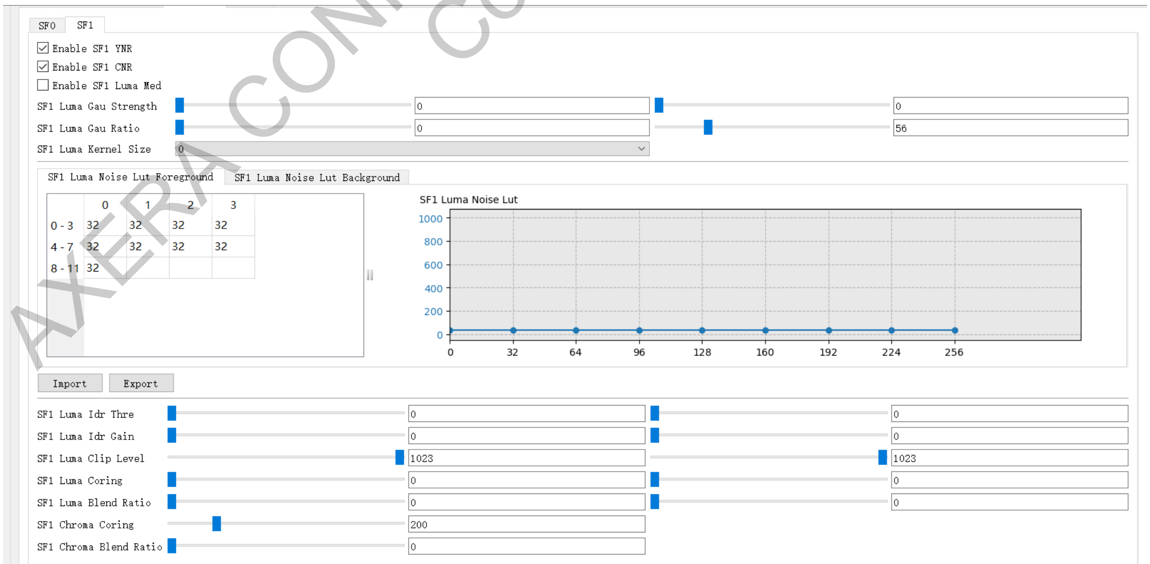


Figure 3-138 Yuv3Dnr_ SF1

<table>
<tr><th colspan="4">YUV3DNR_SF0/SF1</th></tr>
<tr><td>Enable SF0 YNR</td><td colspan="2">SF0 YNR enable switch.</td><td>0 1</td></tr>
<tr><td>Enable SF0 CNR</td><td colspan="2">SF0 CNR enable switch.</td><td>0 1</td></tr>
<tr><td>SF0 Edge Strength</td><td colspan="2">Weight for non-directional edges/directional edges/non-directional texture details. Increasing this value increases the weight for non-directional edge detection. The larger the value, the more areas are detected as non-directional edges. Recommended value: 128.</td><td>0~256</td></tr>
<tr><td>SF0 Dir Strength</td><td colspan="2">Weight for non-directional edges/directional edges/non-directional texture details. Increasing this value increases the weight for directional edge detection. The larger the value, the more areas are detected as directional edges. Recommended value: 128.</td><td>0~256</td></tr>
<tr><td>SF0 Detail Strength</td><td colspan="2">Weight for non-directional edges/directional edges/non-directional texture details. Increasing this value increases the weight for non-directional texture detail detection. The larger the value, the more areas are detected as non-directional texture details. Recommended value: 128.</td><td>0~256</td></tr>
<tr><td>SF0 Luma Noise Lut Flat Foreground</td><td colspan="2">Denoising strength for flat regions in the foreground. The horizontal axis represents luminance, and the vertical axis represents denoising strength.</td><td>0~1023</td></tr>
<tr><td>SF0 Luma Noise Lut Flat Background</td><td colspan="2">Denoising strength for flat regions in the background. The horizontal axis represents luminance, and the vertical axis represents denoising strength.</td><td>0~1023</td></tr>
<tr><td>SF0 Luma Noise Lut Detail Foreground</td><td colspan="2">Denoising strength for textured regions in the foreground. The horizontal axis represents luminance, and the vertical axis represents denoising strength.</td><td>0~1023</td></tr>
<tr><td>SF0 Luma Noise Lut Detail Background</td><td colspan="2">Denoising strength for textured regions in the background. The horizontal axis represents luminance, and the vertical axis represents denoising strength.</td><td>0~1023</td></tr>
<tr><td>SF0 Luma Kernel Size[0][1]</td><td colspan="2">The size of the filter kernel for the foreground/background. The larger the value, the stronger the denoising effect.</td><td>0 1 2 3</td></tr>
<tr><td>SF0 Luma Gau Strength</td><td>SF0 Luma Gau Strength[0] [1]</td><td>Gaussian filter denoising strength for the foreground/background. The larger the value, the stronger the Gaussian denoising effect.</td><td>0~256</td></tr>
<tr><td>SF0 Luma Blend Ratio</td><td>SF0 Luma Blend Ratio[0]: Foreground edge-</td><td>The ratio among edge-preserving denoising, Gaussian denoising, and the original image blending in the</td><td>0~256</td></tr>
</table>

	preserving denoising strength	foreground should sum to 256. The larger the value, the greater the proportion of edge-preserving denoising in the final output.	
	SF0 Luma Blend Ratio[1]: Foreground Gaussian denoising strength	The ratio among edge-preserving denoising, Gaussian denoising, and the original image blending in the foreground should sum to 256. The larger the value, the greater the proportion of Gaussian denoising in the final output.	0~256
	SF0 Luma Blend Ratio[2]: Foreground original image (non-denoised)	The ratio among edge-preserving denoising, Gaussian denoising, and the original image blending in the foreground should sum to 256. The larger the value, the greater the proportion of the original image information in the final output, resulting in weaker denoising.	0~256
	SF0 Luma Blend Ratio[3]: Background edge-preserving denoising strength	The ratio among edge-preserving denoising, Gaussian denoising, and the original image blending in the background should sum to 256. The larger the value, the greater the proportion of edge-preserving denoising in the final output.	0~256
	SF0 Luma Blend Ratio[4]: Background Gaussian denoising strength	The ratio among edge-preserving denoising, Gaussian denoising, and the original image blending in the background should sum to 256. The larger the value, the greater the proportion of Gaussian denoising in the final output.	0~256
	SF0 Luma Blend Ratio[5]: Background original image (non-denoised)	The ratio among edge-preserving denoising, Gaussian denoising, and the original image blending in the background should sum to 256. The larger the value, the greater the proportion of the original image	0~256

		information in the final output, resulting in weaker denoising.	
SF0 Chroma Atten Strength	SF0 Chroma Atten Strength[0] [1]	SF0 foreground/background chroma noise reduction strength. The larger the value, the stronger the chroma noise reduction.	0~1023
SF0 Chroma Atten Limit	SF0 Chroma Atten Limit[0] [1]	SF0 foreground/background chroma noise reduction limit strength. The smaller the value, the stronger the chroma noise reduction.	0~255
SF0 Chroma Prot Lut Foreground	LUT for foreground chroma noise reduction strength based on luminance. The horizontal axis represents luminance, and the vertical axis represents CNR strength. The larger the value, the stronger the chroma noise reduction.		0~1023
SF0 Chroma Prot Lut Background	LUT for background chroma noise reduction strength based on luminance. The horizontal axis represents luminance, and the vertical axis represents CNR strength. The larger the value, the stronger the chroma noise reduction.		0~1023
Enable SF1 YNR	SF1 YNR enable switch.		0 1
Enable SF1 CNR	SF1 CNR enable switch.		0 1
Enable SF1 Luma Med	Enable switch for SF1 LumaMed. It is not recommended to enable this under normal illumination as it can significantly damage details.		0 1
SF1 Luma Gau Strength	SF1 Luma Gau Strength[0] [1]	Gaussian denoising strength for the foreground/background in SF1	0~256
SF1 Luma Gau Ratio	SF1 Luma Gau Ratio[0] [1]	Fusion ratio between Gaussian denoising and edge-preserving denoising for the foreground/background in SF1. The larger the value, the stronger the Gaussian denoising effect, and the weaker the edge-preserving denoising.	0~256
SF1 Luma Kernel Size	The size of the edge-preserving filter kernel in SF1. The larger the value, the more it tends toward low-frequency edge-preserving denoising.		0 1 2
SF1 Luma Noise Lut Foreground/Background	This LUT determines the weight of edge-preserving denoising strength influenced by luminance for the foreground and background. The effectiveness of this		0~1023

	parameter is dependent on the Luma Gau Ratio not being set to 255.		
SF1 Luma Idr Thre	SF1 Luma Idr Thre[0][1]	Isolation point detection threshold for foreground/background in SF1. If a pixel value is greater than the surrounding pixels and exceeds this threshold, it is considered an isolation point. The larger the value, the fewer isolation points are detected.	0~1023
SF1 Luma Idr Gain	SF1 Luma Idr Gain[0][1]	Isolation point suppression strength for foreground/background. The smaller the value, the stronger the noise reduction on isolation points. This is used for denoising isolated noise.	0~256
SF1 Luma Clip Level	SF1 Luma Clip Level[0][1]	Uses the isolation point calculation result to limit the strength of edge-preserving denoising for foreground/background. The smaller the value, the weaker the edge-preserving denoising. The recommended value is 1023.	0~1023
SF1 Luma Coring	SF1 Luma Coring[0][1]	Further noise suppression on the overall foreground/background based on previous denoising results. The larger the value, the blurrier the image. It is recommended to set this to 0 if noise is not severe.	0~1023
SF1 Luma Blend Ratio	SF1 Luma Blend Ratio[0] [1]	Fusion ratio between the Gaussian denoising/edge-preserving denoising result and the original image for foreground/background. The smaller the value, the larger the proportion of SF1 denoising results, leading to stronger denoising. The larger the value, the higher the proportion of original image information, resulting in weaker denoising.	0~256

SF1 Chroma Coring	The suppression strength of the chroma noise reduction result. The larger the value, the stronger the chroma noise reduction.	0~1023
SF1 Chroma Blend Ratio	The fusion ratio between the chroma noise reduction result and the original image. The larger the value, the weaker the chroma noise reduction.	0~256

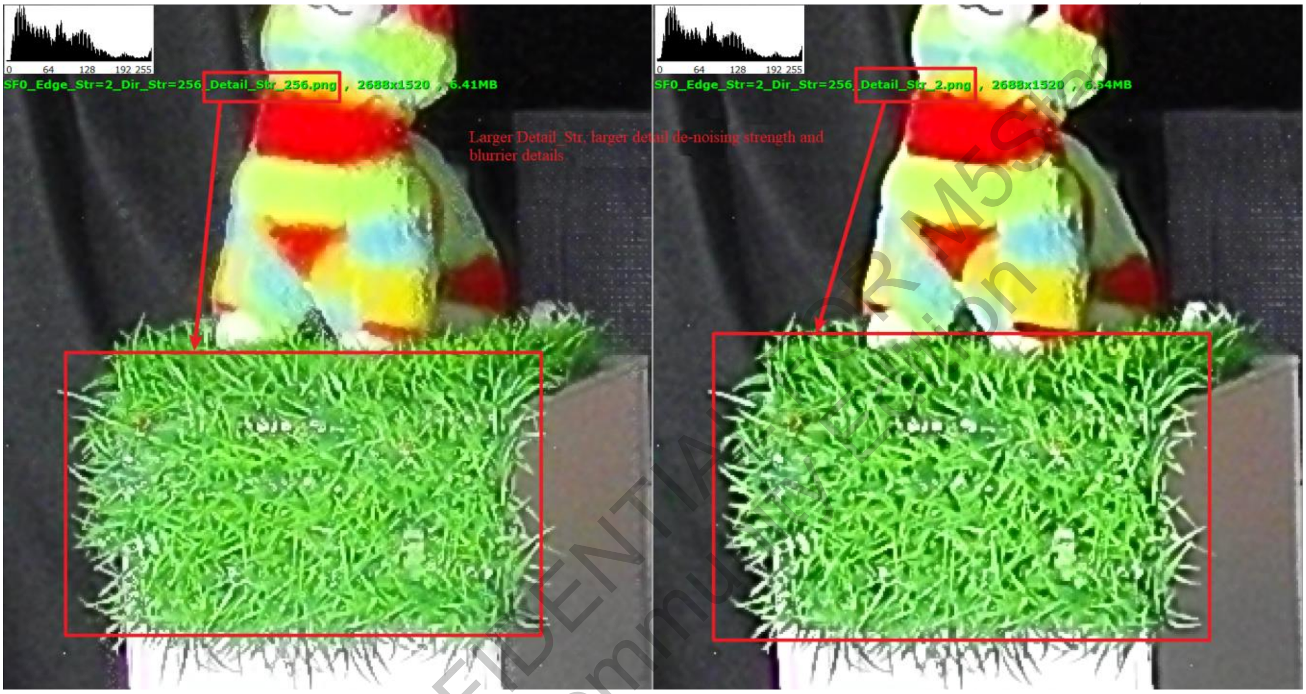


Figure 3-139 Yuv3Dnr_ SF0_Detail_Str Effect

Figure 3-140 Yuv3Dnr_ SF0_Edge_Str Effect

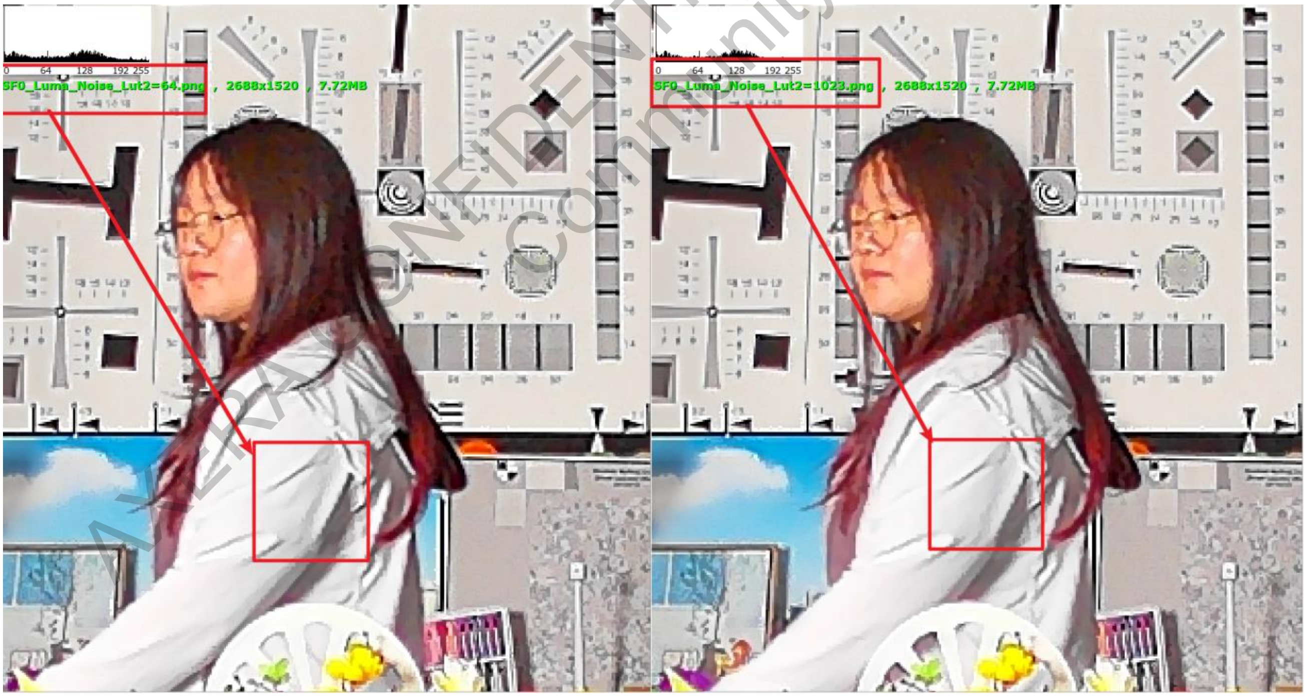


Figure 3-141 Yuv3Dnr_SF0_Luma_Noise_Lut Foreground De-noising Effect

Figure 3-142 Yuv3Dnr_SF0_Luma_Noise_Lut Background De-noising Effect

Figure 3-143 Yuv3Dnr_ SF1_Luma_Noise_Lut Background De-noising Effect

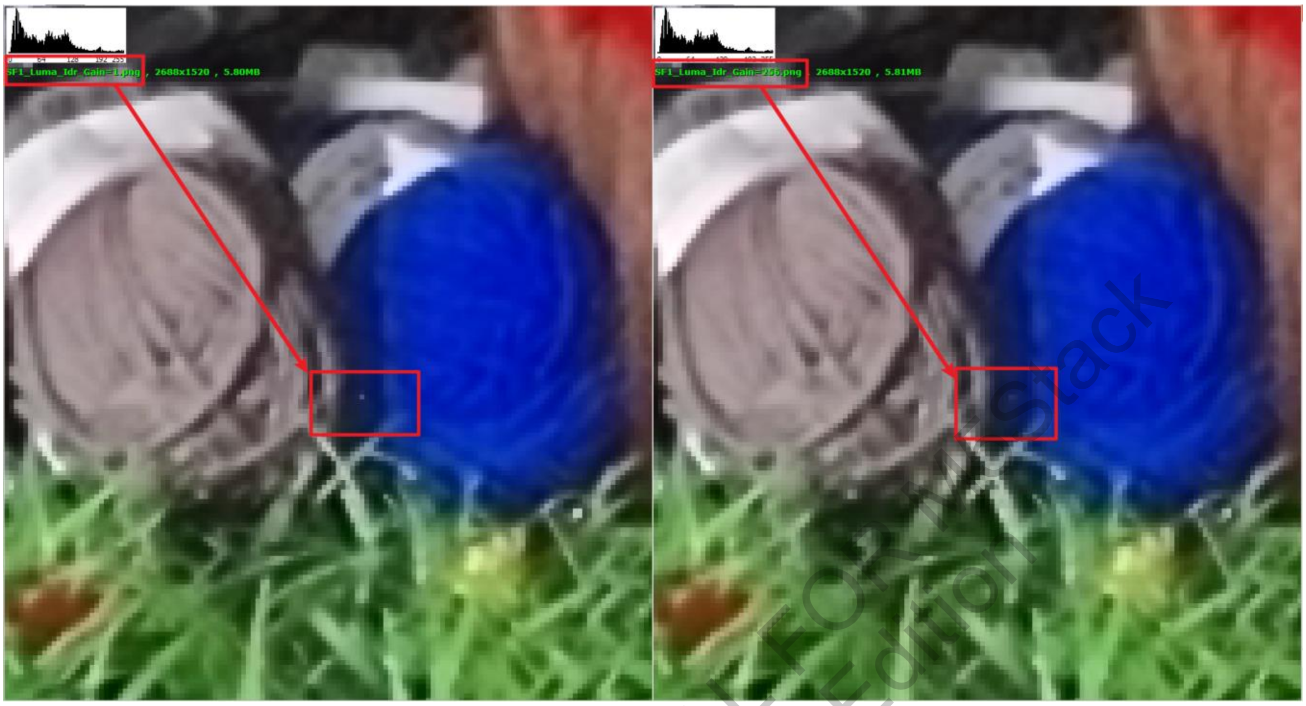


Figure 3-144 Yuv3Dnr_SF1_Luma_Idr_Gain Effect

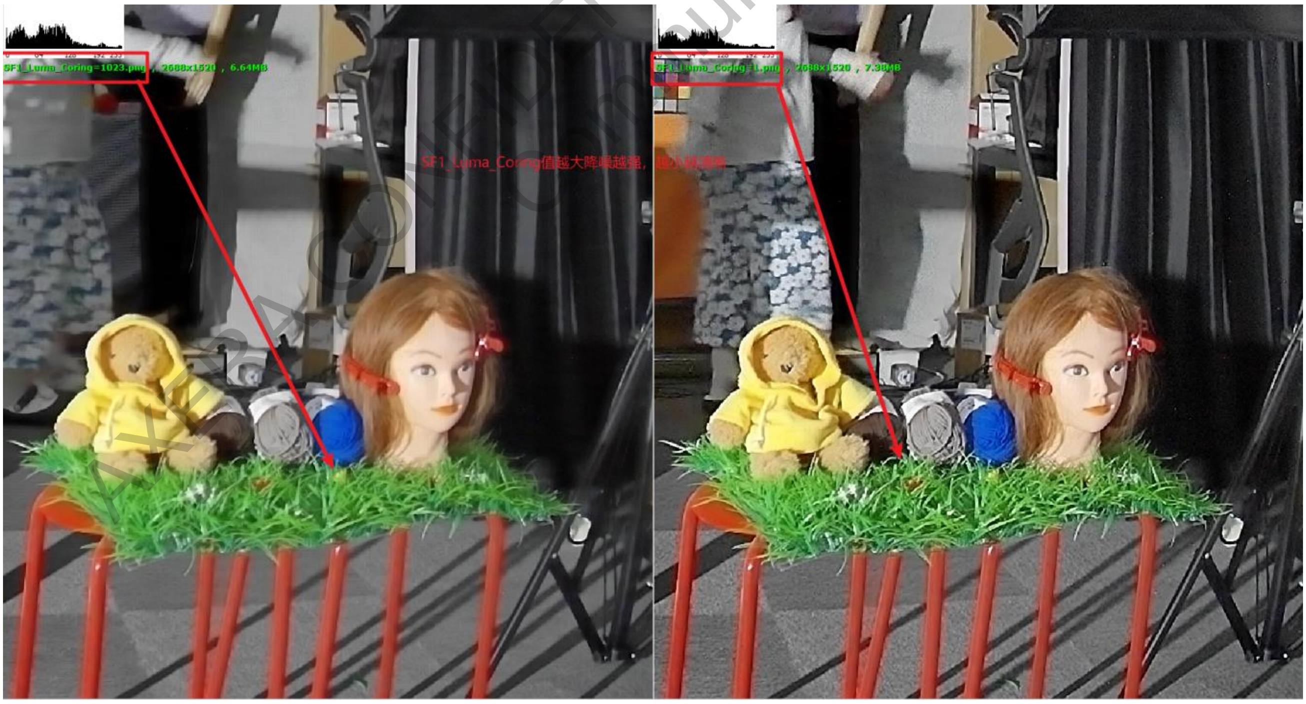


Figure 3-145 Yuv3Dnr_ SF1_Luma_Coring Effect

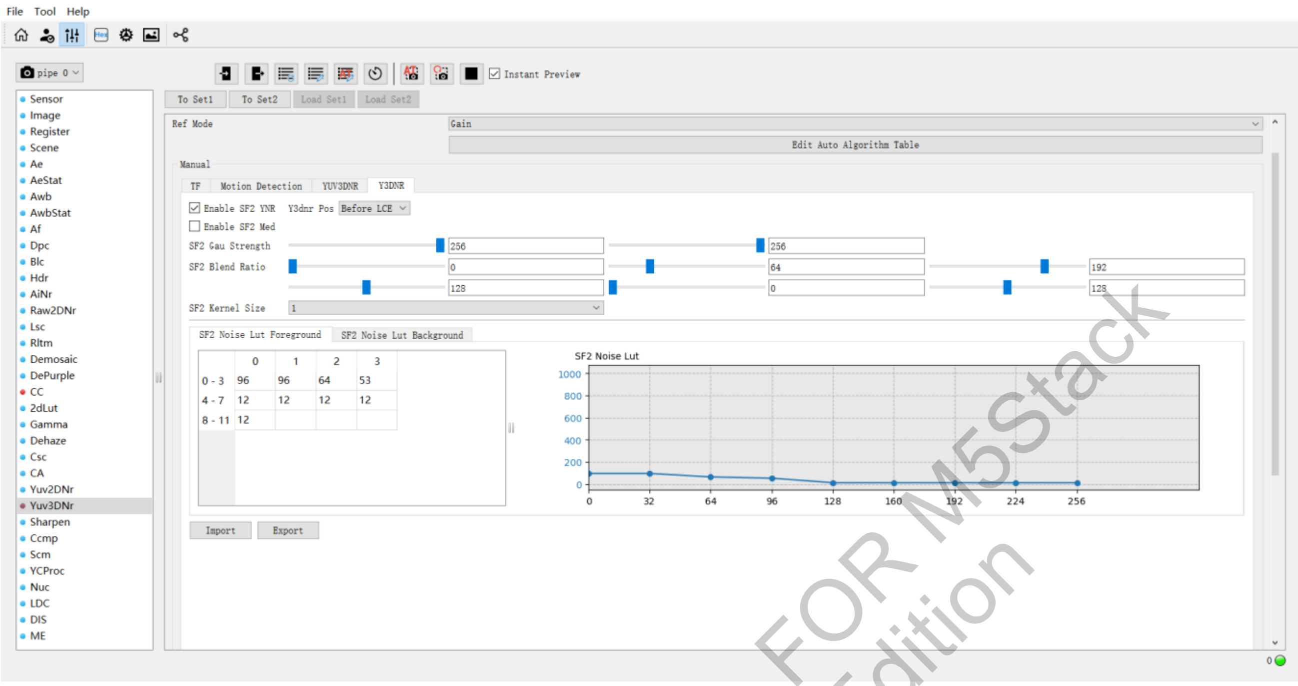


Figure 3-146 Y3Dnr_SF2

<table>
<tr><th colspan="4">Y3DNR_SF2</th></tr>
<tr><td>Name</td><td colspan="2">Description</td><td>Value</td></tr>
<tr><td>Enable SF2 YNR</td><td colspan="2">Enable switch for SF2 denoising</td><td>0 1</td></tr>
<tr><td>Y3dnr Pos</td><td colspan="2">The position of SF2 denoising in the pipeline:
Before LCE: SF2 denoising will be applied before sharpening.
After LCE: SF2 denoising will be applied after sharpening.</td><td>Before LCE/After LCE</td></tr>
<tr><td>Enable SF2 Med</td><td colspan="2">Enable switch for SF2 Median filtering (Med). Enabling this feature results in stronger denoising and is recommended for high-gain conditions. It is suggested to keep this off under normal illumination to prevent excessive detail loss.</td><td>0 1</td></tr>
<tr><td>SF2 Gau Strength</td><td>SF2 Gau Strength[0][1]</td><td>Gaussian filter strength for SF2 foreground/background. The larger the value, the stronger the Gaussian filtering.</td><td>0~256</td></tr>
<tr><td rowspan="2">SF2 Blend Ratio</td><td>SF2 Blend Ratio[0]</td><td>SF2 foreground edge-preserving denoising fusion ratio.</td><td>0~256</td></tr>
<tr><td>SF2 Blend Ratio[1]</td><td>SF2 foreground Gaussian denoising fusion ratio.</td><td>0~256</td></tr>
</table>

	SF2 Blend Ratio[2]	SF2 foreground original image information fusion ratio.	0~256
	SF2 Blend Ratio[0]	SF2 background edge-preserving denoising fusion ratio.	0~256
	SF2 Blend Ratio[1]	SF2 background Gaussian denoising fusion ratio.	0~256
	SF2 Blend Ratio[2]	SF2 background original image information fusion ratio.	0~256
SF2 Kernel Size	The size of the edge-preserving denoising filter kernel for SF2. The larger the value, the more it tends toward low-frequency edge-preserving denoising.		0 1
SF2 Noise Lut [0][1]	LUT for the weight of edge-preserving denoising strength influenced by luminance for foreground/background. The horizontal axis represents luminance, and the vertical axis represents edge-preserving denoising strength.		0~1023

3.21.4 Debugging Steps

1. Motion detection:

   1) In TIISP mode, motion detection primarily relies on the Motion Detection module in Yuv3Dnr. In this mode, there is no External Mask, so you need to disable External Mask Enable or set the values in External Mask Ratio_Luma/Chroma/Status to 0, as shown below:

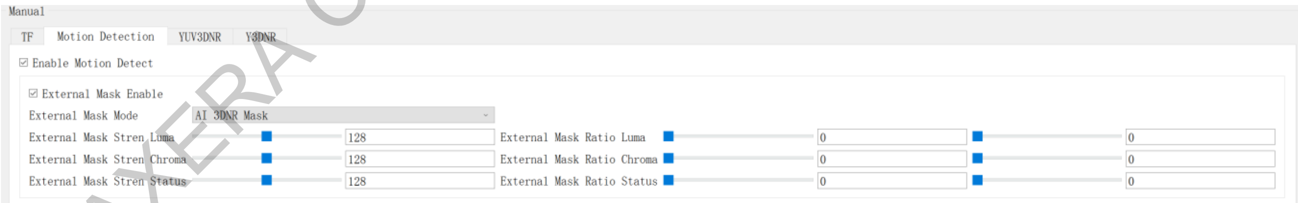


Figure 3-147 Yuv3Dnr_ TIISP_Motion Detection Configuration

   2) Configure the Motion Detect score table. The recommended configuration is as follows:

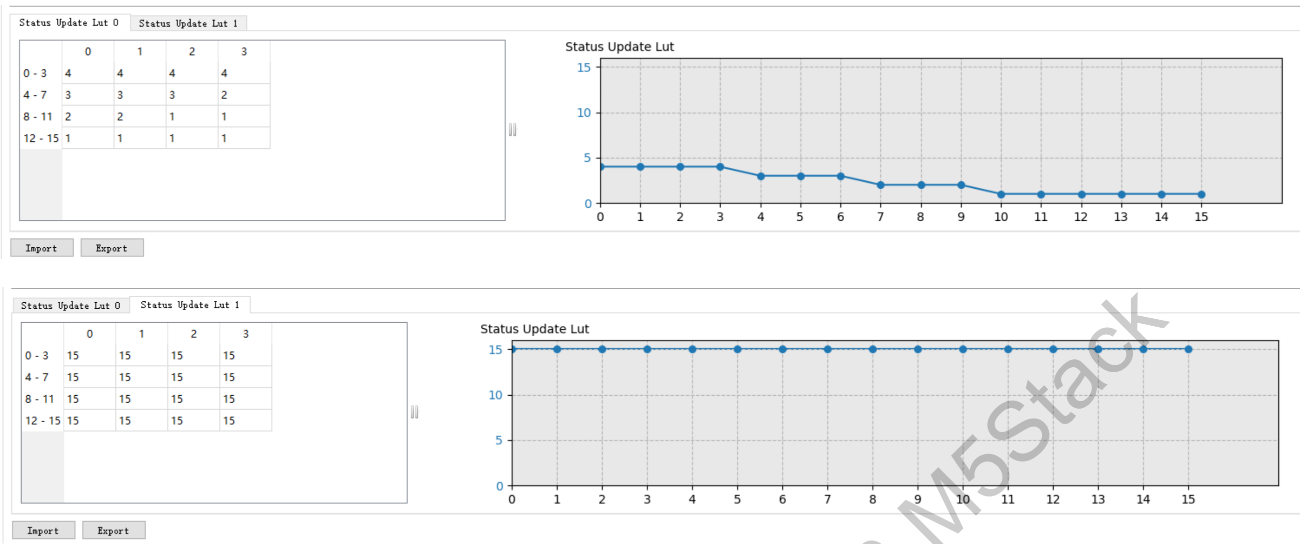


Figure 3-148 Yuv3Dnr_ Motion Detection_Status Update

3) Configure Motion Det parameter:

- Using Y Channel Motion Detection Results: Set Motion Det Blend Ratio[0][1] to 256.
- Using UV Channel Motion Detection Results: Set Motion Det Blend Ratio[0][1] to 0.
- Blending Y and UV Channel Motion Detection Results: Set to other values for blending.

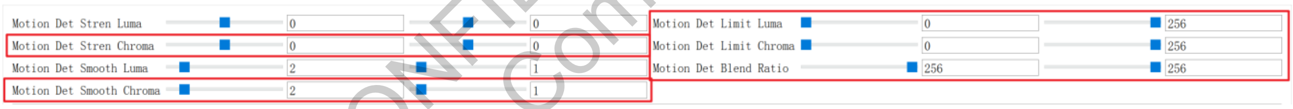


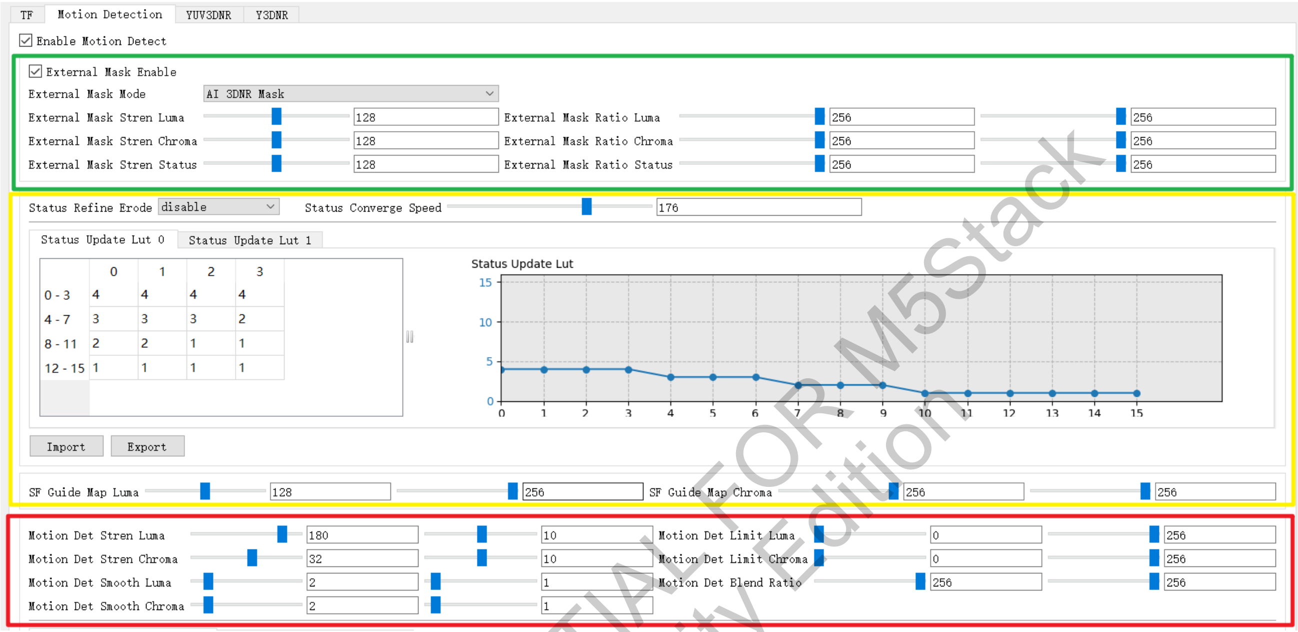
Figure 3-149 Yuv3Dnr_ Motion Detection Configuration

It is recommended to use the Y channel for motion detection. The suggested configuration parameters are shown in the figure, where the parameters within the red box do not need further adjustment. Fine-tune Motion Det Stren Luma and Motion Det Smooth Luma according to the motion detection results.

4) Configure Mot Det Noise Lut

Motion Det Noise LUT Luma/Chroma: These tables are the motion detection curves for the Y and UV domains, respectively. The larger the value on the vertical axis, the more likely the corresponding luminance is judged as a stationary region. During debugging, it is suggested to first configure the Mot Det Blend Ratio to use only the Y mode and adjust the first curve. Then configure it to use only the UV mode and adjust the second curve.

5) Configure Motion Detect Parameter in AIISP Mode



	0	1	2	3
0 - 3	4	4	4	4
4 - 7	3	3	3	2
8 - 11	2	2	1	1
12 - 15	1	1	1	1

Figure 3-150 Yuv3Dnr_ Motion Detection Configuration

In AIISP mode, the Motion Detect parameter configuration can refer to the figure above. The recommended configuration for External Mask Detect parameters is as shown in the green box, which mainly relies on the motion detection results provided by the model. Parameters in the Red Box: Mostly ineffective in this mode.

Parameters in the Yellow Box: Can be adjusted according to actual conditions.

➢ Common image issues and debugging methods:

1) To addressing flickering noise in static areas, use a tool to read the luminance of the affected area. Increase the LUT table values for the corresponding luminance area. If noise persists, adjust the values in the Motion Det Noise LUT Chroma for the UV domain.

2) To address increased ghosting when moving objects pass through dark areas, decrease the LUT values for dark areas until the ghosting is reduced and there is no significant flickering noise in the dark areas.

3) To address noticeable blockiness, where some areas have different denoising strength compared to surrounding areas, ensure the LUT table curve is smooth to minimize differences in motion detection across different luminance regions.

2. Adjusting temporal intensity:

In normal illumination, configure the TF Ratio Limit as shown in the figure below. Adjust the limit range from 0~255 to 16~255 or 32~255 to reduce temporal intensity and avoid ghosting.

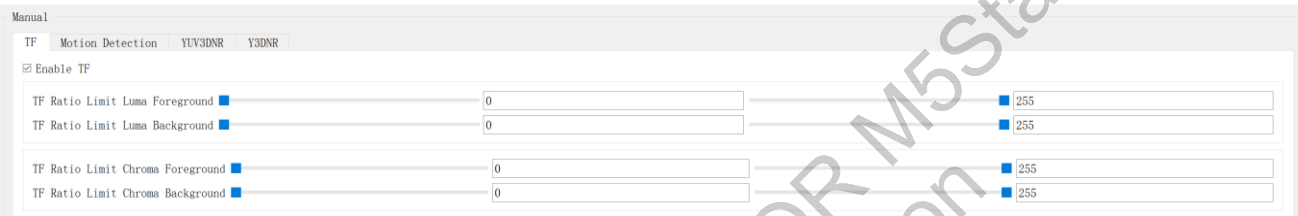


Figure 3-151 Yuv3Dnr_ TF

TF Ratio Lut can be configured as the following figure shows. The vertical axis represents the blending ratio between the current frame and the reference frame. Larger values indicate a higher proportion of the current frame, resulting in weaker temporal filtering. Horizontal axis represents the cumulative status score calculated from the Status Update LUT 0/1 tables. Larger values indicate a higher likelihood of being a static region. Horizontal axis (0-15) is from motion to static regions. The vertical axis of TF Ratio Lut is the blending ratio from motion to static regions, with larger values indicating a higher proportion of the current frame.

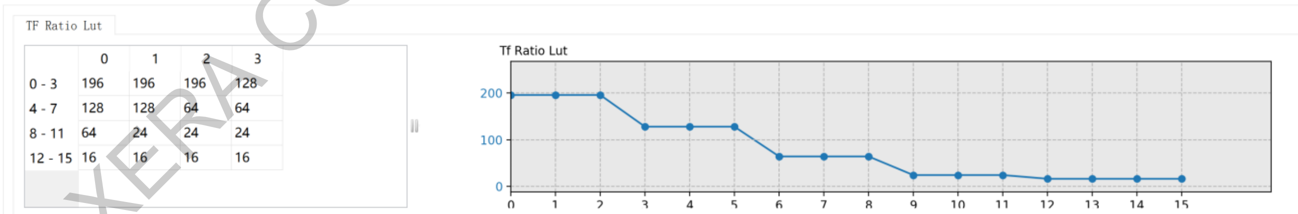


Figure 3-152 Yuv3Dnr_ TF_Ratio_Lut

3. Adjusting spatial denoising:

Yuv3Dnr comprises of Yuv3Dnr and Y3DNR, with Yuv3Dnr consisting of SF0 and SF1, and Y3DNR consisting of SF2. Y3DNR can adjust the position of Sharpen in the PipeLine.

- SF0+SF1+Sharpen+SF2: Recommended for retaining details while controlling noise after sharpening.

- SF0+SF1+SF2+Sharpen: Recommended for cleaner noise processing with less impact from sharpening, though it may result in some detail loss.
- SF0: Reduces low-to-mid frequency noise.
  SF1: Handles high-frequency noise.
  SF2: Similar to SF1 but applied after the second temporal filtering, while SF1 is applied before the second temporal filtering, and SF0 is applied before the first temporal filtering. Debugging sequence: SF0 → SF2 → SF1

4. Debugging mode of Yuv3Dnr:

   1) echo 0 > /tmp/yuv3dnr_debug_mode_0 (Normal image output)
   2) echo 1 > /tmp/yuv3dnr_debug_mode_0 (Motion mask)
   3) echo 2 > /tmp/yuv3dnr_debug_mode_0 (SF Guide mask)
   4) echo 3 > /tmp/yuv3dnr_debug_mode_0 (TF Guide mask)

☞ In the image of debugging mode, white is the mask area, black is the non-mask area, gray is the transition area, and colored areas has no specific meaning. You only need to pay attention to the black/white/gray areas.

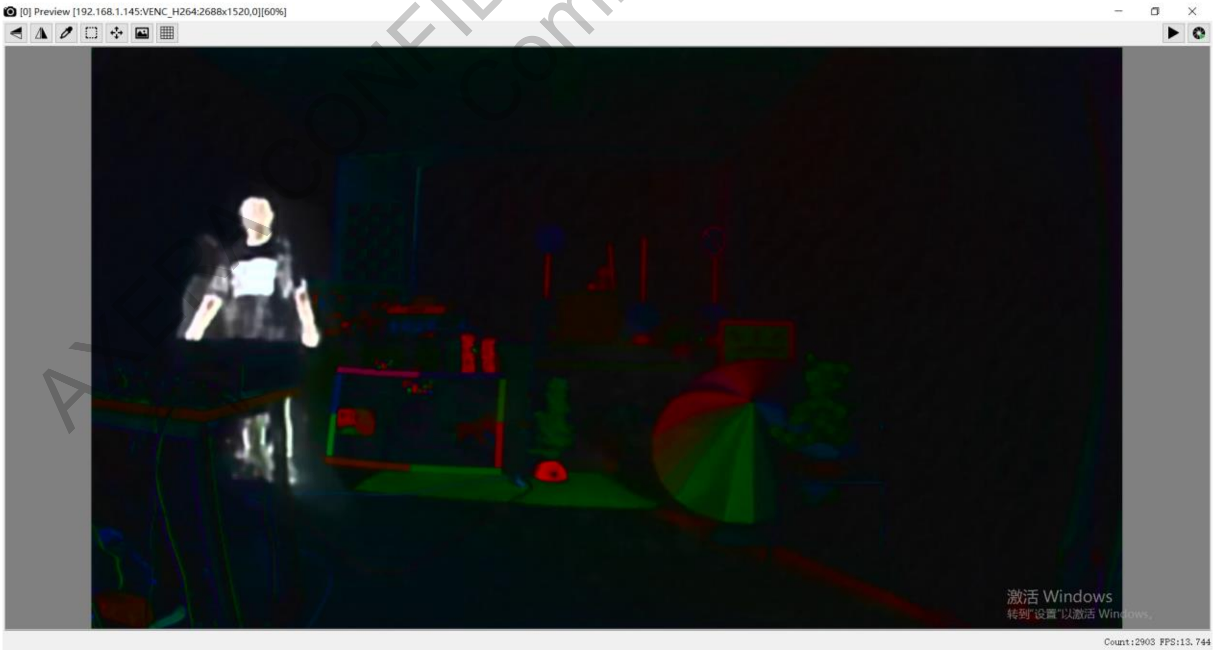


Figure 3-153 Yuv3Dnr_ Debug_Motion mask

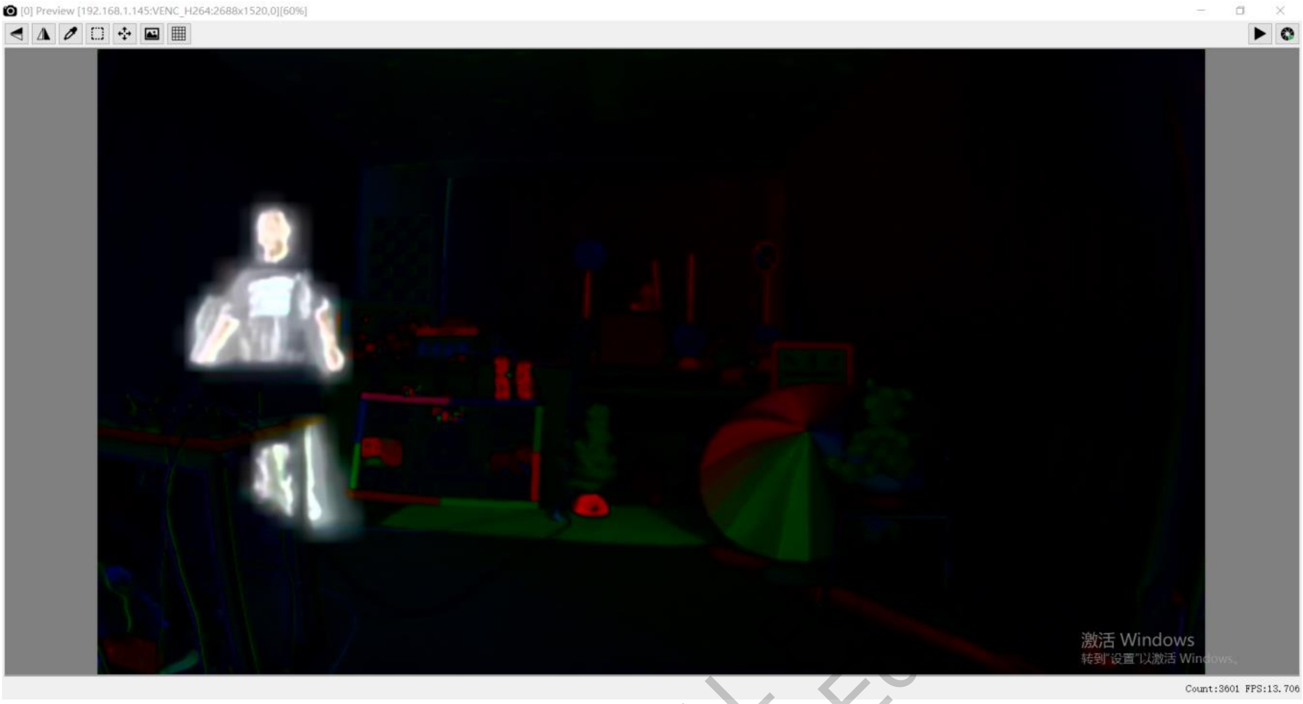


Figure 3-154 Yuv3Dnr_Debug_SF Guide mask

Figure 3-155 Yuv3Dnr_Debug_TF Guide mask

3.22 Yuv2DNr

3.22.1 Introduction

Yuv2DNr is used for the removal of luminance and chroma noise in the YUV domain.

3.22.2 Interface

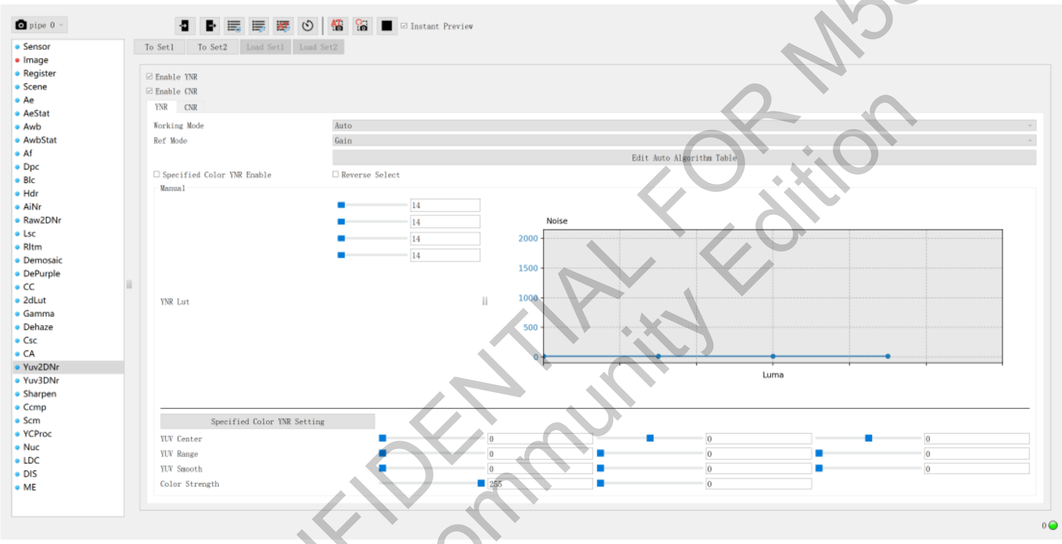


Figure 3-156 Yuv2Dnr

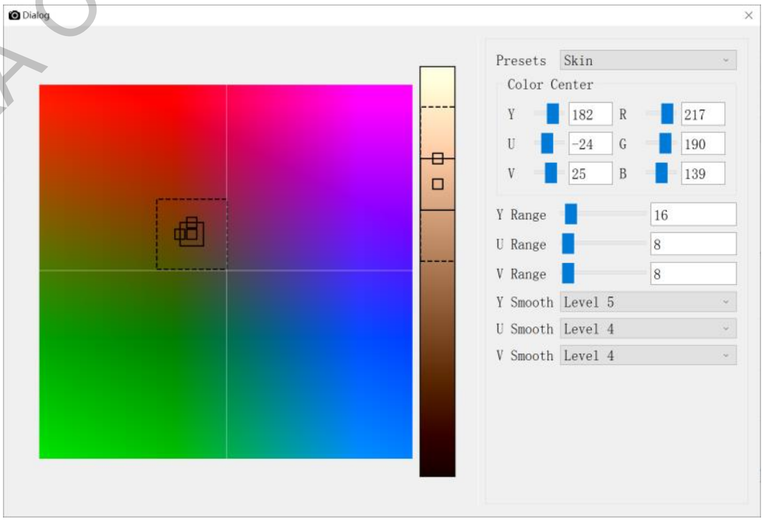


Figure 3-157 Specified Color YNR Select

3.22.3 Parameter

<table>
<tr><th colspan="4">YUV_2DNR_YNR</th></tr>
<tr><th>Parameter</th><th colspan="2">Description</th><th>Range</th></tr>
<tr><td>Enable YNR</td><td colspan="2">Enable switch for luminance noise reduction</td><td>0 1</td></tr>
<tr><td>Enable CNR</td><td colspan="2">Enable switch for chromia noise reduction</td><td>0 1</td></tr>
<tr><td>Working Mode</td><td colspan="2">Manual/Auto</td><td>Manual/Auto</td></tr>
<tr><td>Ref Mode</td><td colspan="2">Selection of reference value type. This value determines the basis for Ref Val in the Auto Algorithm Table.
When Ref Val is Lux, current parameters change with illuminance.
When Ref Val is gain, current parameters change with gain.</td><td>Lux/gain</td></tr>
<tr><td>Edit Auto Algorithm Table</td><td colspan="2">Allows editing of the automatic parameter configuration table</td><td></td></tr>
<tr><td>Specified Color YNR Enable</td><td colspan="2">Enable switch for luminance noise reduction on specified colors.
0: off; 1: on.
If Specified Color YNR Enable is not turned on, all pixels use the YNR strength of Color Strength[0].</td><td>0 1</td></tr>
<tr><td>Reverse Select</td><td colspan="2">Enable switch for applying luminance noise reduction to the complementary color of the specified color. 0: off; 1: on.</td><td>0 1</td></tr>
<tr><td>YNR Lut</td><td colspan="2">LUT for YNR noise reduction strength. The larger the value, the weaker the noise reduction; the smaller the value, the stronger the noise reduction. It is recommended that the values at each point in the LUT table be the same or have small differences.</td><td>0~2047</td></tr>
<tr><th colspan="4">Specified Color YNR Select</th></tr>
<tr><td rowspan="4">Presets</td><td>Skin</td><td>Preset data for skin color</td><td>/</td></tr>
<tr><td>Plants</td><td>Preset data for green plants</td><td>/</td></tr>
<tr><td>License Plate(Blue)</td><td>Preset data for blue license plates</td><td>/</td></tr>
<tr><td>License Plate(Green)</td><td>Preset data for green license plates.</td><td>/</td></tr>
<tr><td>Color Center Y/U/V</td><td colspan="2">The center values of Y/U/V for the specified preferred color</td><td>0~1023</td></tr>
<tr><td>Y/U/V Range</td><td colspan="2">The radius values of Y/U/V for the specified preferred color</td><td>0~511</td></tr>
<tr><td>Y/U/V Smooth</td><td colspan="2">The range for the smooth transition zone of the preferred color Y/U/V.
If the pixel's Y/U/V value differs from the preferred color by more than the Y/U/V Range, its strength will gradually transition smoothly to the non-preferred color area.
There are 8 levels of transition smoothness: Level 0 to Level 7.</td><td>0~7</td></tr>
</table>

Color Strength	Color Strength[0]: YNR strength. It is recommended to set this value to 255. Color Strength[1]: CNR strength. When preferred color noise reduction is not used, it is recommended to set this value to 0.	0~255
YUV_2DNR_CNR		
Working Mode	Manual/Auto	Manual/Auto
Ref Mode	Selection of reference value type. This value affects the Ref Val in the Auto Algorithm Table. Lux: Parameters change with illumination. Gain: Parameters change with gain.	/
Edit Auto Algorithm Table	Allows editing of the automatic parameter configuration table	/
CNR Strength	Chroma noise reduction strength parameter. The larger the value, the stronger the chroma noise reduction; the smaller the value, the weaker the chroma noise reduction.	0~16
CNR Lut	LUT for chroma noise reduction based on different luminance levels. The horizontal axis represents the Luma value, and the vertical axis represents the chroma noise intensity. The larger the value, the weaker the chroma noise reduction; the smaller the value, the stronger the chroma noise reduction.	0~2047

3.22.4 Debugging Steps

YUV2DNR is divided into two parts: YNR and CNR, which can be adjusted separately.

1、YNR Tuning:

1) Adjusts YNR noise strength LUT. Horizontal axis is the luminance, and vertical axis is the noise intensity. Larger values result in weaker noise reduction, while smaller values result in stronger noise reduction. It is recommended to set similar or close values across the LUT to avoid uneven noise reduction transitions at different luminance levels.

2) Special Color YNR Noise Reduction:

- Enable Special Color YNR feature.
- Set preferred colors in Special Color YNR Setting. Use preset data for skin tones, green plants, blue license plates, and green license plates as needed. Refer to Figure 3-120 for

blue license plates.

- After setting the desired color, adjust the Color Strength parameter accordingly, as shown in Figure 3-121.

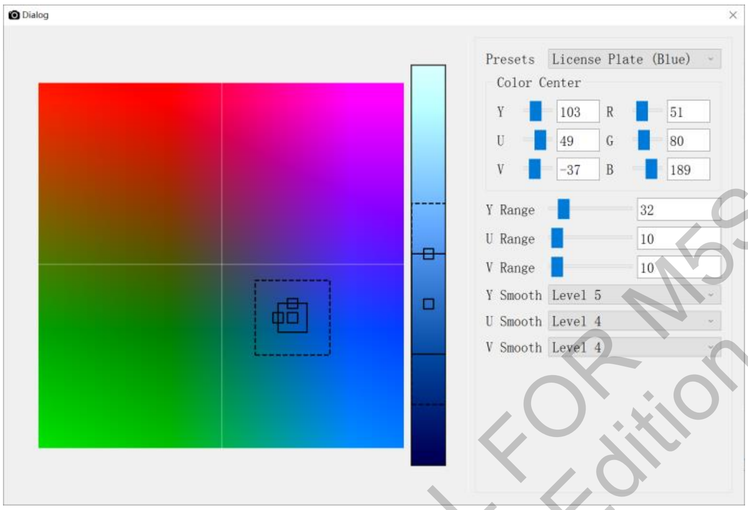


Figure 3-158 Specified Color YNR Select

Figure 3-159 Specified Color YNR Select

2、CNR Tuning:

1) Adjusts CNR Strength and LUT. Horizontal axis is the luminance, and vertical axis is the noise intensity. Larger values result in weaker noise reduction, while smaller values result in stronger noise reduction. It is recommended to set similar or close values across the LUT to avoid uneven noise reduction transitions at different luminance levels.

2) It is recommended to set the CNR strength, targeted at high-frequency chroma noise, higher to effectively reduce chroma noise.

3.23 Sharpen

3.23.1 Introduction

The Sharpen module enhances image clarity by sharpening or smoothing edges. It allows for independent sharpening of directional edges and non-directional texture details. The module supports adjusting the sharpening strength based on pixel luminance and separately for motion and static regions. Additionally, it supports independent control of overshoot and undershoot for motion/static regions and coring based on noise intensity. By adjusting the areas and frequency bands to be enhanced, various clarity enhancement styles can be achieved.

3.23.2 Interface

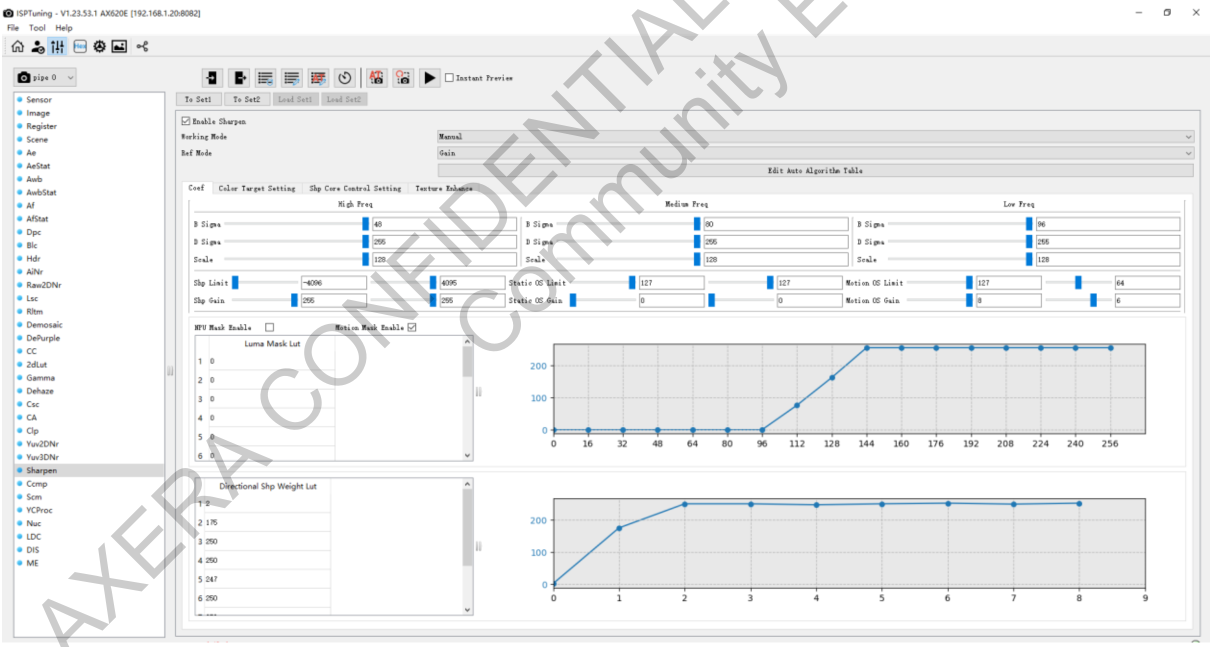


Figure 3-160 Sharpen

3.23.3 Parameter

Parameter	Description	Range
Enable Sharpen	Function switch, check to enable	0.1

Working Mode		Auto/manual working mode selection	Auto/Manual
Ref Mode		Automate parameters based on Lux/Gain, distinguishing each level	Lux/Gain
Edit Auto Algorithm Table		Edit the automatic algorithm parameter configuration table	/
High/Medium/Low Freq	B Sigma	Represents a base frequency band. Setting it to 0 means full pass.	High: 0~48 Medium: 0~80 Low: 0~96
	D Sigma	Represents a delta frequency band. A value of 1 indicates moving one sigma towards the lower frequency band from the base band. Smaller Sigma: Sharper edges. Larger Sigma: Softer edges.	0~255
	Scale	Filter strength. The larger the value, the greater the weight of the corresponding frequency band. Default is 128 (100% strength).	0~128
Shp Limit[0][1]		Sharpening intensity limits to restrict the maximum sharpening strength. Shp Limit[0]: Black edge sharpening intensity limit. Shp Limit[1]: White edge sharpening intensity limit.	[0]: -4096~0 [1]: 0~4095
Shp Gain[0][1]		The larger the value, the more pronounced the black/white edges. Shp Gain[0]: Black edge sharpening strength. Shp Gain[1]: White edge sharpening strength.	[0]: 16~255 [1]: 16~255
Static OS_Limit[0][1]		Overshoot limit for static regions. Larger values mean stronger limits, resulting in weaker black/white edges. OS_Limit[0]: Black edge limit value. OS_Limit[1]: White edge limit value.	[0]: 0~127 [1]: 0~127
Static OS_Gain[0][1]		Overshoot strength for static regions. Larger values mean stronger black/white edges. OS_Gain[0]: Black edge overshoot strength. OS_Gain[1]: White edge overshoot strength.	[0]: 0~8 [1]: 0~8
Motion OS_Limit[0][1]		Overshoot limit for motion regions. Larger values mean stronger limits, resulting in weaker black/white edges. OS_Limit[0]: Black edge limit value. OS_Limit[1]: White edge limit value.	[0]: 0~127 [1]: 0~127

Motion OS_Gain[0][1]	Overshoot strength for motion regions. Larger values mean stronger black/white edges. OS_Gain[0]: Black edge overshoot strength. OS_Gain[1]: White edge overshoot strength.	[0]: 0~8 [1]: 0~8
Luma Mask Lut	Adjust Mask LUT based on Luma to modify the sharpening effect at different luminance levels.	0~255
Derectional Shp Weight Lut	Adjust directional sharpening weight based on Luma. The larger the value, the stronger the sharpening effect.	0~255

☞ Recommended Values for Bsigma and Dsigma:

High-frequency Bsigma: 8 ~ 16, Dsigma: 16 ± 4
Mid-frequency Bsigma: 24 ~ 36, Dsigma: 36 ± 8
Low-frequency Bsigma: 26 ~ 42, Dsigma: 52 ± 12

Parameter Adjustment Effect

- Taking MF adjustment for example. In the left image, Bsigma is 28 and Dsigma is 32. This configuration tends to sharpen smaller detail textures. In the right image, Bsigma is 40 and Dsigma is 32. This configuration tends to sharpen larger texture edges.

Figure 3-161 Bsigma\Dsigma Effect

- Taking LF adjustment for example. In the left image, Shp Gain[0][1] is 20, 20; in the right image, Shp Gain[0][1] is 120, 120. The strength of black and white edges is weaker compared to the right image.

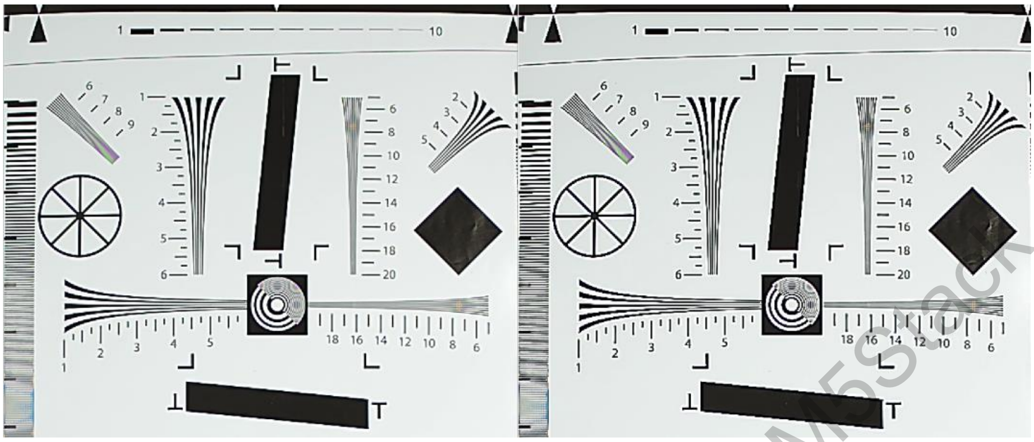


Figure 3-162 Shp Gain Effect

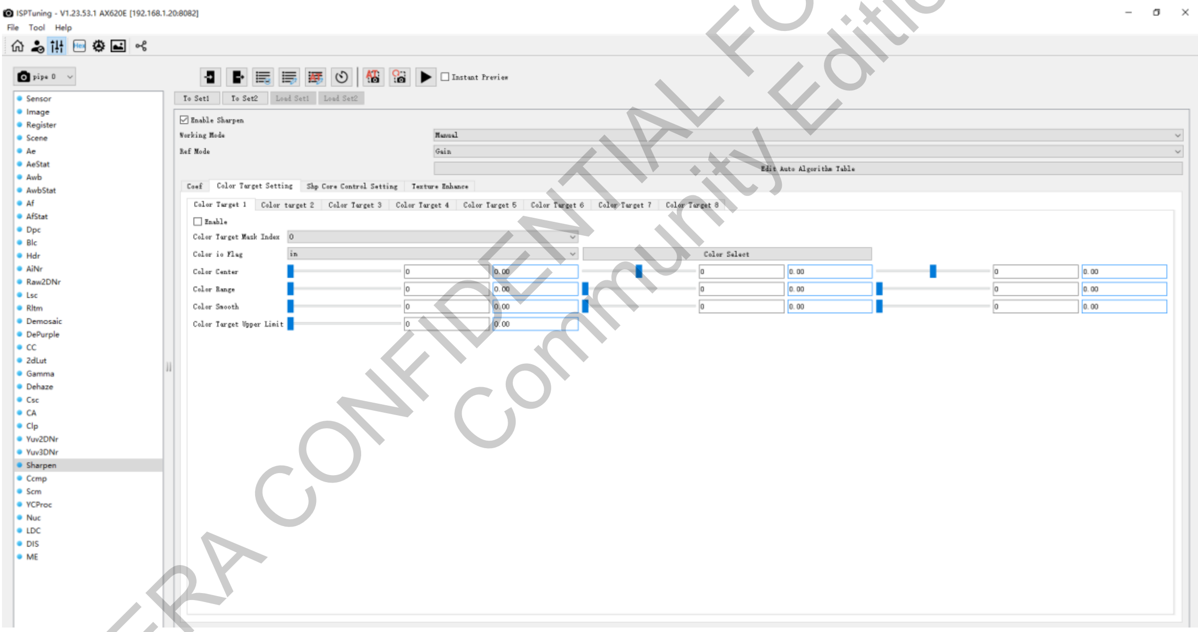


Figure 3-163 Color Target Setting

Color Target Setting		
Parameter	Description	Range
Enable	Switch to enable.	0.1
Color Target Mask Index	Select the Color Mask index. Each index corresponds to a specific color of interest to be set separately.	0/1/2/3
Color io Flag	In: Select this color. Out: Invert the selection of this color.	in/out

Color Select	Select the color range by framing it.			
Color Center	The center of the color to be sharpened separately, such as skin tone or green plants. It is recommended to select this using the framing tool rather than setting it manually.	0~1023	0~511	0~511
Color Range	The effective color range. It is recommended to select this by using the framing tool rather than setting it manually.	0~511	0~511	0~511
Color Smooth	The transition range. It is recommended to select this using the framing tool rather than setting it manually.	0~7	0~7	0~7
Color Target Upper Limit	The upper limit of the color value.	0~128		

Parameter Adjustment Effect

➢ The effect of weakening the sharpening for skin tones and enhancing the sharpening for green plants is shown in the figure below.

Figure 3-164 Sharpen _Color Skin Tone Sharpening Effect

Figure 3-165 Sharpen _Color Green Plant Sharpening Effect

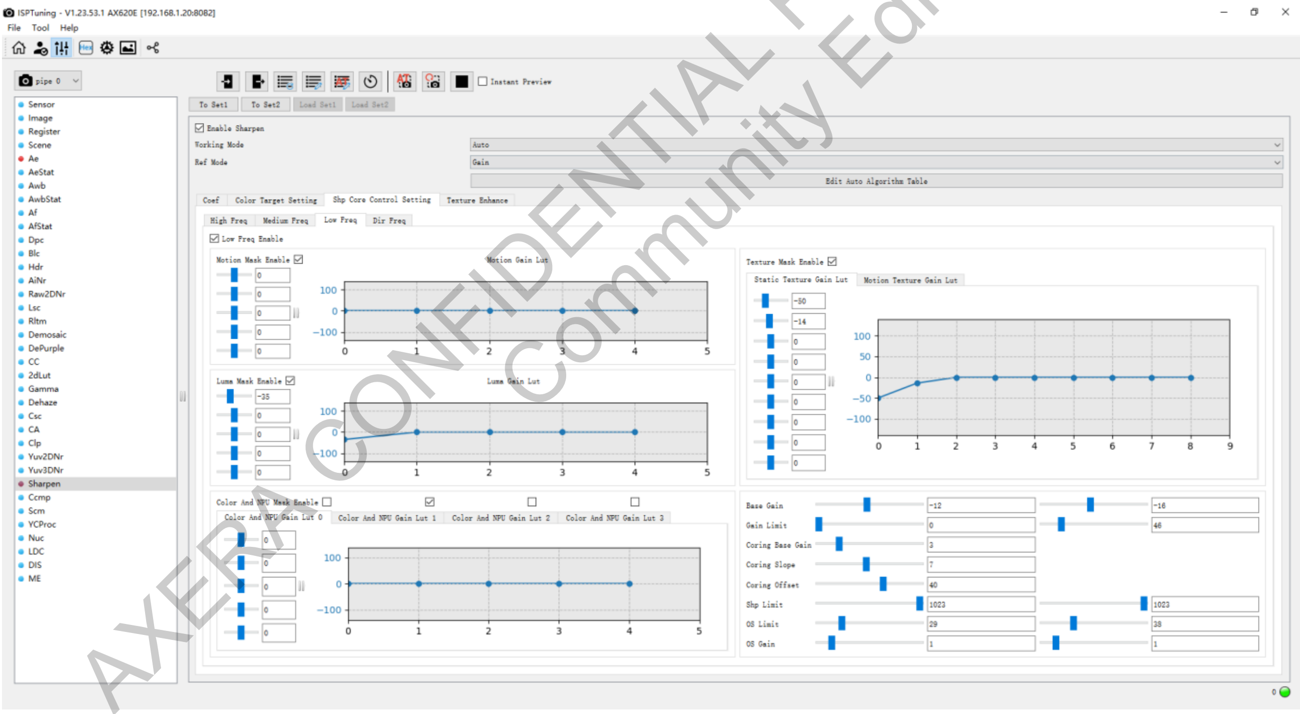


Figure 3-166 Shp Core Control Setting

Shp Core Control Setting		
Parameter	Description	Range
High/Medium/Low/Dir Freq Enable	Switch to enable.	0.1
Motion Mask Enable	Toggle for motion mask	0.1

Motion Gain Lut	Adjust sharpening strength based on motion. The larger the value, the stronger the sharpening effect.	[-128, -127]
Luma Mask Enable	Toggle for brightness mask	0.1
Luma Gain Lut	Adjust sharpening strength based on brightness. The larger the value, the stronger the sharpening effect.	[-128, -127]
Texture Mask Enable	Toggle for enabling texture region masking	0.1
Static Texture Gain Lut	Sharpening strength curve for static texture regions. The larger the value, the stronger the sharpening effect.	[-128, -127]
Motion Texture Gain Lut	Sharpening strength curve for motion texture regions. The larger the value, the stronger the sharpening effect.	[-128, -127]
Color And NPU Mask Enable	Toggle for enabling color mask.	0.1
Color And NPU Gain Lut	Four index groups for adjusting sharpening intensity based on color. The larger the value, the stronger the sharpening effect.	[-128, -127]
Base Gain	Base sharpening strength. The larger the value, the stronger the sharpening effect. Example: A value of 0 represents a gain of 2^0 = 1x Gain. The first value is for black edge strength. The second value is for white edge strength.	[-256, 255]
Gain Limit	Limits the sharpening intensity. The larger the value, the stronger the sharpening effect. The first value is the lower limit for sharpening intensity. The second value is the upper limit for sharpening intensity.	[0, 255]
Coring Base Gain	Used to limit high-frequency noise and handle horizontal/vertical stripes or flat region grid noise. Affects high-frequency clarity; use with caution.	[0, 15]

Coring Slope	Affects edge detection. Smaller values detect more edges, while larger values detect fewer edges.	[0, 15]
Coring Offset	Compensation for edge detection judgment, used in conjunction with Coring Slope to adjust edge strength.	[0, 63]
Shp Limit	Ensures a minimum global sharpening intensity. Larger values result in a higher minimum sharpening intensity.□ The first value is for black edge limit.□ The second value is for white edge limit.	[0, 1023]
OS Limit	Black and white edge limit for preventing overshoot.□ The first value is for black edge limit.□ The second value is for white edge limit.	[0, 127]
OS Gain	Overshoot strength for black and white edges. Larger values result in stronger black and white edges. The first value is for black edge strength.□ The second value is for white edge strength.	[0, 8]

- Before and after motion sharpening is enabled:

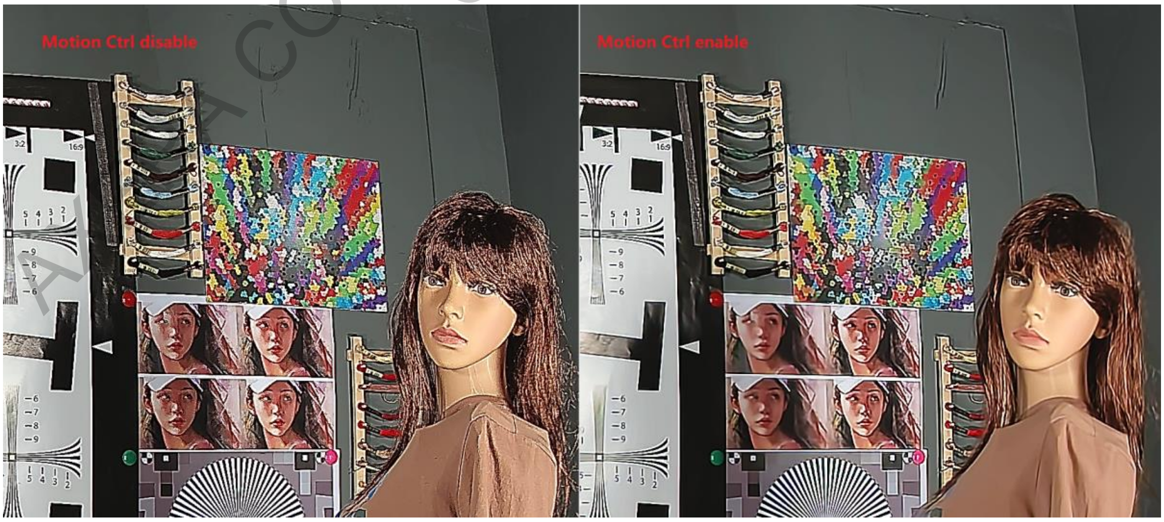


Figure 3-167 Motion Ctrl Effect

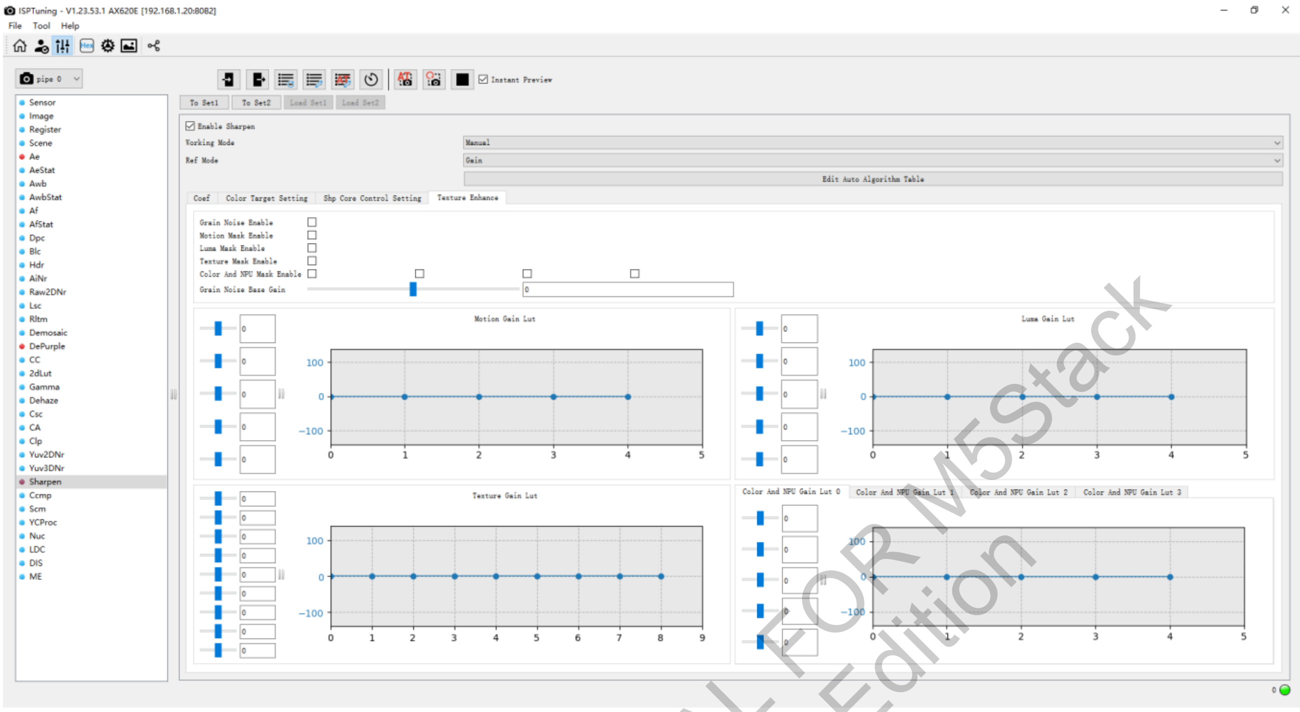


Figure 3-168 Texture Enhance

Texture Enhance		
Parameter	Description	Range
Grain Noise Enable	Enable switch. Recommended not to enable.	0.1
Motion Mask Enable		0.1
Luma Mask Enable		0.1
Texture Mask Enable		0.1
Color And NPU Mask Enable		0.1
Grain Noise Base Gain	Grain noise strength	[-256, 255]
Motion Gain Lut	Motion-sharpening gain curve	[-128, 127]
Luma Gain Lut	Brightness-sharpening gain curve	[-128, 127]
Texture Gain Lut	Texture-sharpening gain curve	[-128, 127]
Color And NPU Gain Lut 0 - 3	Color/NPU-sharpening curve	[-128, 127]

☞ Texture Enhance is used to add noise to the image. It is not recommended to enable this feature as it can degrade image quality.

Sharpen Debug

- echo CODE > /tmp/shp_debug_mode_0
- Example: Use the command “echo 5 > /tmp/shp_debug_mode_0” to enable the Sharpen Debug

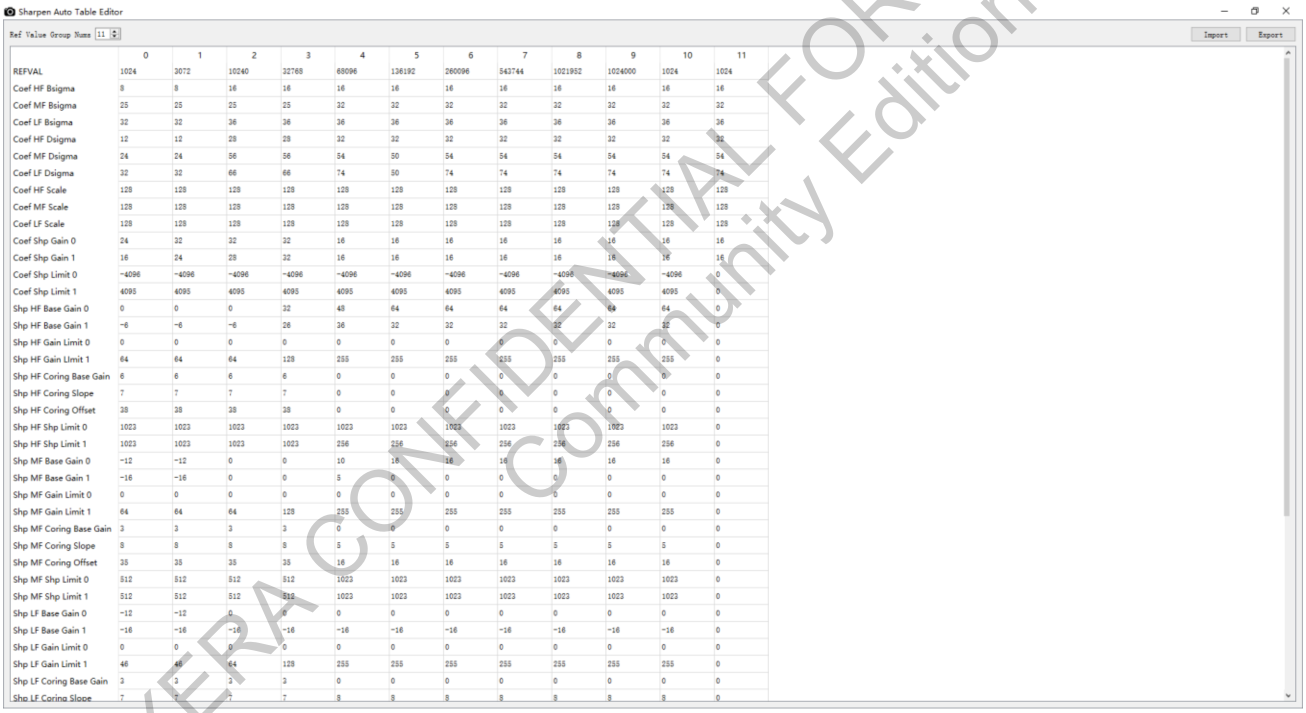
feature. After inputting this command, click “write” in the Sharpen interface to display the Debug image.

NORMAL = 0	Close debugging and output a normal image
GRAIN = 3	Show grain noise
HF = 4	Show details after all four sharpening cores with various gain/LUT/OS controls and overlays
MOTION = 5	Show the motion mask
LUMA = 6	Show the luma mask
NOISEY = 7	Show noise level
CLNP0 = 8	Show color mask 0
CLNP1 = 9	Show color mask 1
CLNP2 = 10	Show color mask 2
CLNP3 = 11	Show color mask 3
TEXTURE3 = 12	Show texture information detected in the HF window
TEXTURE5 = 13	Show texture information detected in the MF window
TEXTURE7 = 14	Show texture information detected in the LF window
DIRCONF = 15	Show edge information, which is also the blend coefficient with MF
SGC3 = 24	Show HF gain map, indicating which areas have gain suppressed or enhanced (e.g., dark areas, flat areas, color target areas)
SGC5 = 25	Show MF gain map
SGD5 = 26	Show DF gain map
SGC7 = 27	Show LF gain map
HFC3 = 28	HF detail map

HFC5 = 29	MF detail map
HFD5 = 30	DF detail map
HFC7 = 31	LF detail map

☞ Do not rely solely on Debug mode to judge high, medium, directional, and low-frequency sharpening. Use the actual image effect as the primary basis for tuning and Debug mode as an auxiliary reference to understand how changes affect the image.

3.23.4 Auto mode



Sharpen Auto Table Editor

Ref Value Group Nums 11

Import Export

	0	1	2	3	4	5	6	7	8	9	10	11
REFVAL	1024	3072	10240	32768	68096	136192	260096	543744	1021952	1024000	1024	1024
Coef HF Bsigma	8	8	16	16	16	16	16	16	16	16	16	16
Coef MF Bsigma	25	25	25	25	32	32	32	32	32	32	32	32
Coef LF Bsigma	32	32	36	36	36	36	36	36	36	36	36	36
Coef HF Dsigma	12	12	28	28	32	32	32	32	32	32	32	32
Coef MF Dsigma	24	24	56	56	54	50	54	54	54	54	54	54
Coef LF Dsigma	32	32	66	66	74	50	74	74	74	74	74	74
Coef HF Scale	128	128	128	128	128	128	128	128	128	128	128	128
Coef MF Scale	128	128	128	128	128	128	128	128	128	128	128	128
Coef LF Scale	128	128	128	128	128	128	128	128	128	128	128	128
Coef Shp Gain 0	24	32	32	32	16	16	16	16	16	16	16	16
Coef Shp Gain 1	16	24	28	32	16	16	16	16	16	16	16	16
Coef Shp Limit 0	-4096	-4096	-4096	-4096	-4096	-4096	-4096	-4096	-4096	-4096	-4096	0
Coef Shp Limit 1	4095	4095	4095	4095	4095	4095	4095	4095	4095	4095	4095	0
Shp HF Base Gain 0	0	0	0	32	48	64	64	64	64	64	64	0
Shp HF Base Gain 1	-6	-6	-6	26	36	32	32	32	32	32	32	0
Shp HF Gain Limit 0	0	0	0	0	0	0	0	0	0	0	0	0
Shp HF Gain LImit 1	64	64	64	128	255	255	255	255	255	255	255	0
Shp HF Coring Base Gain	6	6	6	6	0	0	0	0	0	0	0	0
Shp HF Coring Slope	7	7	7	7	0	0	0	0	0	0	0	0
Shp HF Coring Offset	38	38	38	38	0	0	0	0	0	0	0	0
Shp HF Shp Limit 0	1023	1023	1023	1023	1023	1023	1023	1023	1023	1023	1023	0
Shp HF Shp Limit 1	1023	1023	1023	1023	256	256	256	256	256	256	256	0
Shp MF Base Gain 0	-12	-12	0	0	10	16	16	16	16	16	16	0
Shp MF Base Gain 1	-16	-16	0	0	5	0	0	0	0	0	0	0
Shp MF Gain Limit 0	0	0	0	0	0	0	0	0	0	0	0	0
Shp MF Gain Limit 1	64	64	64	128	255	255	255	255	255	255	255	0
Shp MF Coring Base Gain	3	3	3	3	0	0	0	0	0	0	0	0
Shp MF Coring Slope	8	8	8	8	5	5	5	5	5	5	5	0
Shp MF Coring Offset	35	35	35	35	16	16	16	16	16	16	16	0
Shp MF Shp Limit 0	512	512	512	512	1023	1023	1023	1023	1023	1023	1023	0
Shp MF Shp Limit 1	512	512	512	512	1023	1023	1023	1023	1023	1023	1023	0
Shp LF Base Gain 0	-12	-12	0	0	0	0	0	0	0	0	0	0
Shp LF Base Gain 1	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	-16	0
Shp LF Gain Limit 0	0	0	0	0	0	0	0	0	0	0	0	0
Shp LF Gain Limit 1	46	46	64	128	255	255	255	255	255	255	255	0
Shp LF Coring Base Gain	3	3	3	3	0	0	0	0	0	0	0	0
Shp LF Coring Slope	7	7	7	7	8	8	8	8	8	8	8	0

Figure 3-169 Auto mode

In Auto mode, all Sharpen parameters will be linked with gain/Lux. The strength of various Sharpen parameters will change accordingly with gain/Lux.

3.23.5 Debugging Steps

Sharpen Tuning

1) Enable sharpening by turning on shp_enable. Disable all masks: motion, texture, luma, and color.

2) Set static/motion overshoot gain and overshoot gain for each frequency band to 0.

3) Set global shp_gain to 16 (1x gain), global shp_limit to (-4096, 4095), base gain for each frequency band to 0, and gain limit for each frequency band to 255. (Note: Base gain is represented in logarithmic form; 0 means 2^0.0 = 1x gain, 32 means 2^1.0 = 2x gain, etc.)

4) Adjust high, medium, and low-frequency b sigma and d sigma. Use the sharpen debug command to fine-tune the details filtered by each frequency band. Remember: the larger b sigma + d sigma, the coarser the detected edges.

5) Adjust the base gain to meet the sharpening requirements for each frequency band. Noise in the image might be significant at this stage; you can address this later.

   a) Enable luma mask and set luma gain LUT if you need to adjust sharpening intensity for specific luminance regions.
   b) Enable texture mask and set static texture gain LUT/motion texture gain LUT if different sharpening intensities are needed for different texture strength regions.
   c) Set motion LUT to 0 initially. Adjust static texture gain LUT first, then adjust motion texture gain LUT. Ensure the motion LUT does not differ significantly from the static LUT.
   d) Enable motion mask and set motion gain LUT if separate sharpening intensity for motion areas is needed.
   e) Enable color and NPU mask and set corresponding LUTs for different colors and NPU mask regions.

6) Adjust gain limits for each frequency band to avoid overexposure or underexposure in image edges.

7) Adjust overshoot limits and gains for each frequency band to keep edge overshoot within acceptable limits.

8) Adjust coring base gain, coring slope, and coring offset to reduce the sharpening effect on noise. Note: This adjustment may weaken the sharpening of weak textures. You can use texture gain LUT to compensate.

9) Adjust directional shp weight LUT to control the blend ratio between edge directional sharpening (dir freq) and uniform sharpening across high, medium, and low frequencies.

10) Adjust global shp gain and shp limit to increase or decrease the overall sharpening intensity and amplitude.

11) (Optional) Adjust shoot control for static and motion areas separately. Relax shoot limits for motion areas to enhance black and white edges and improve perceived sharpness.

Detail Enhancement Tuning (Optional)

Adjusts Grain Noise Base Gain to fine-tune the clarity and uniformity of image details and noise. It is generally not recommended to enable this feature.

3.24 CCMP

3.24.1 Introduction

CCMP (Chroma Compensation) module is designed to correct color effects or adjust color preferences in the image.

3.24.2 Interface

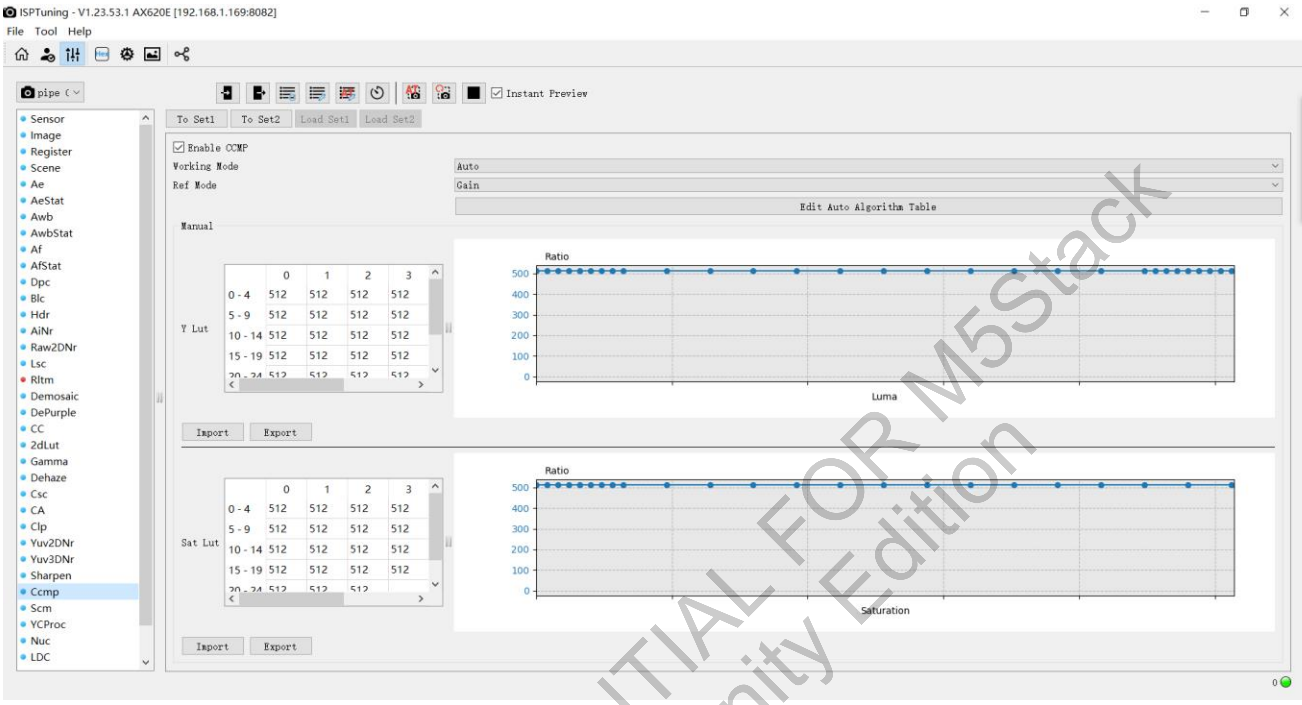


Figure 3-170 CCMP

3.24.3 Parameter

Parameter	Description	Range
Enable CCMP	CCMP enable	/
Working Mode	Manual/Auto	/
Ref Mode	Lux/Gain	/
Edit Auto Algorithm Table	Automatic clgorithm configuration table	/
Y Lut	Adjusts saturation based on brightness.Horizontal axis is luminance, and vertical axis is saturation.	0~512
Sat Lut	Adjusts saturation based on saturation.Both horizontal and vertical axises represent saturation.	0~512

- Note: The horizontal axis intervals of Y Lut Ratio/Sat Lut Ratio are not evenly distributed. There is a higher density of control points in dark, bright, and low saturation areas, while other areas have a lower density of control points.

3.24.4 Debugging Recommendation

- This module allows for the reduction of saturation using either luminance or saturation adjustments. The method chosen depends on the specific scenario or the yous preference. Value of 512 represents 1x, meaning no saturation reduction; while value of 0 represents complete saturation reduction to 0. To reduce color noise, use saturation → saturation. To adjust the brightness and saturation style, use luma → saturation.

3.24.5 Auto mode

Parameter Description

- Working Mode
  - Description: Switches between auto/manual mode
  - Parameter
    - Manual: In manual mode, parameters can be freely adjusted.
    - Auto: In automatic mode, parameters are adjusted based on gain/luminance as reference values.
- Ref Mode
  - Choice of reference value type for the automatic strategy, which affects the meaning of Ref Val in the Auto Algorithm Table.
  - Parameter
    - Lux: In this mode, Ref Val in the Auto Algorithm Table is actually the Lux value. This parameter changes with the illuminance.
    - Gain: In this mode, Ref Val in the Auto Algorithm Table is actually the gain. This parameter changes with the gain.
- Ref Val
  - Displays the current numerical value of Ref Val.

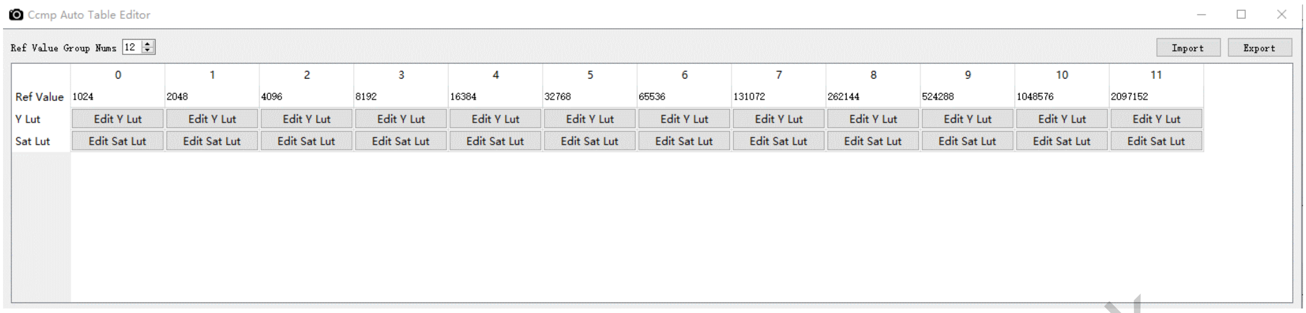


Figure 3-171 CCMP Auto Table

3.25 SCM

3.25.1 Introduction

SCM (Special Color Mapping) is used to correct color effects or adjust color preferences by replacing specific YUV colors with other colors. Colors within a defined range in the YUV space will be completely replaced by the target color. Colors near the boundary of the defined range will be partially modified based on a gradient attenuation. If you need to tune the SCM, use the Color Select tool in the Sharpen module to determine the YUV values and the range of colors that need to be modified.

3.25.2 Interface

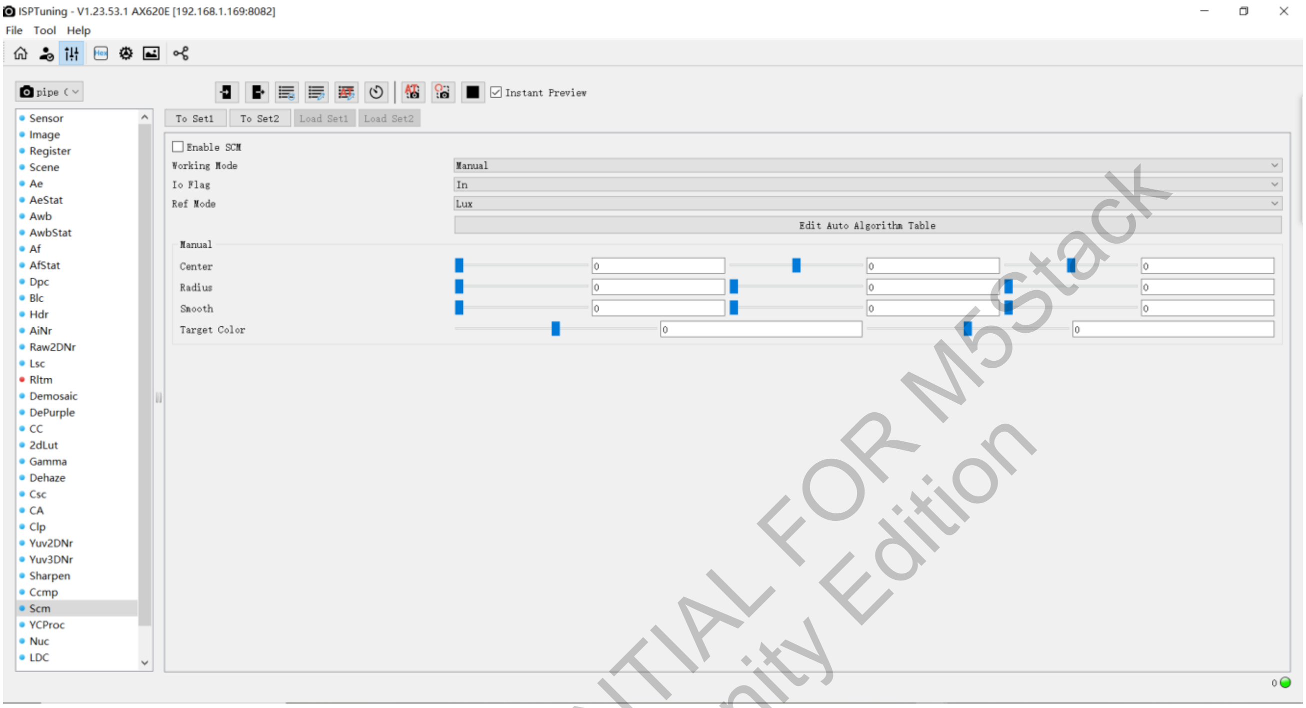


Figure 3-172 SCM

3.25.3 Parameter

Parameter	Description	Range
Enable SCM	Toggle switch for the SCM feature	/
Working Mode	Manual/Auto	/
Io Flag	In	/
	Out: Inverted selection	/
Ref Mode	Lux/Gain	/
Edit Auto Algorithm Table	Configure auto parameter table	/
Center	Center[0]: Grayscale value of the pixel to be replaced	0~1023
	Center[1]: Color value of the pixel to be replaced	-512~511
	Center[2]: Color value of the pixel to be replaced	-512~511
Radius	Radius[0]: Influence range of the grayscale value to be replaced	0~511
	Radius[1]: Influence range of the color value to be replaced	0~511

Parameter	Description	Range
	Radius[2]: Influence range of the color value to be replaced	0~511
Smooth	Smooth[0]: Smoothing strength for the grayscale value influence range	0~7
	Smooth[1]: Smoothing strength for the color value influence range	0~7
	Smooth[2]: Smoothing strength for the color value influence range	0~7
Target Color	Target Color[0]: Target color (U value) for the replaced pixel	-512~511
	Target Color[1]: Target color (V value) for the replaced pixel	-512~511

3.25.4 Debugging Recommendation

Determine the desired UV values for the target color. For instance, if you want to convert the colors in dark, low-saturation areas to 0, set the target UV values to 0. Gradually increase the center YUV values until you effectively reduce the saturation in the dark, low-saturation regions to 0.

3.25.5 Auto mode

Parameter Description

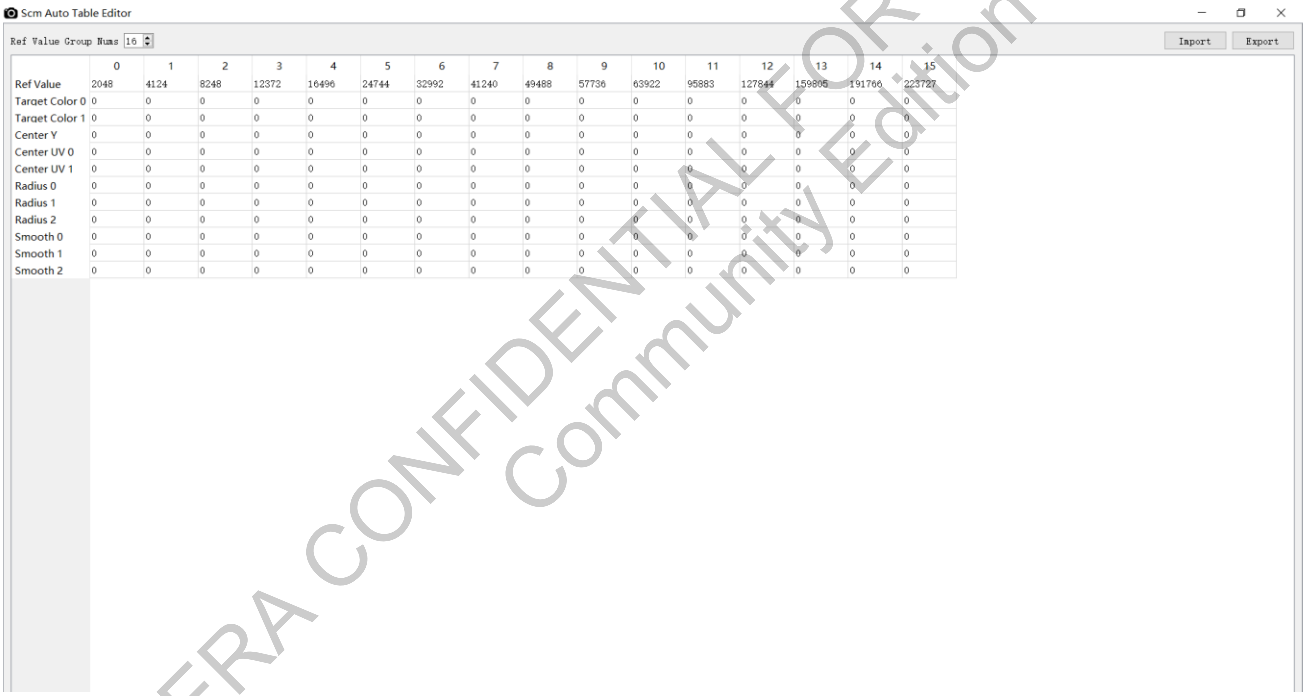
- Working Mode
  - Description: Switches between auto/manual mode
  - Parameter
    - Manual: In manual mode, parameters can be freely adjusted.
    - Auto: In automatic mode, parameters are adjusted based on gain/luminance as reference values.
- Ref Mode
  - Choice of reference value type for the automatic strategy, which affects the meaning of Ref

Val in the Auto Algorithm Table.

- Parameter
  - Lux: In this mode, Ref Val in the Auto Algorithm Table is actually the Lux value. This parameter changes with the illuminance.
  - Gain: In this mode, Ref Val in the Auto Algorithm Table is actually the gain. This parameter changes with the gain.

➢ Ref Val

- Displays the current numerical value of Ref Val.



	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ref Value	2048	4124	8248	12372	16496	24744	32992	41240	49488	57736	63922	95883	127844	159805	191766	223727
Target Color 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Target Color 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Center Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Center UV 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Center UV 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Radius 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smooth 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smooth 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smooth 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 3-173 SCM Auto Table

3.26 YCProc

3.26.1 Introduction

The YCProc module includes two sub-modules: Ycrt and YC Proc.

- Ycrt Sub-module configures the output luminance and chroma data range in the YUV domain to adapt to the encoding format. Compared to the CSC module, Ycrt can preserve more information during early processing stages. If luminance and chroma data range processing (limit range) is needed, it is recommended to use the Ycrt module and set the CSC module to full range.
- YC Proc sub-module provides basic image adjustment functions including global adjustments of brightness, saturation, contrast, and hue.

3.26.2 Interface

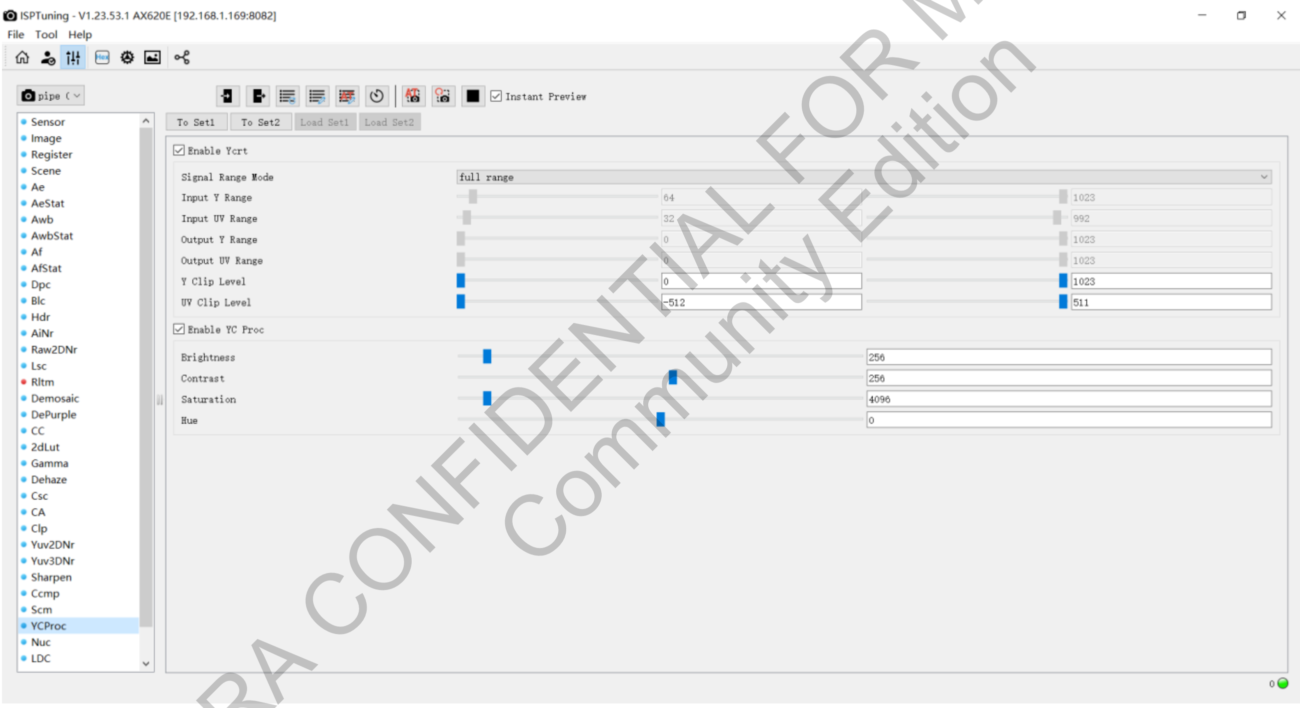


Figure 3-174 YCProc

3.26.3 Parameter

Parameter	Description	Range
Enable Ycrt	YCRT enable	0 1
Signal Range Mode	full range	/
	limit range	/
	custom	/

Parameter	Description	Range
Input Y Range	Input Y Range[0]: Input grayscale range	0~1023
	Input Y Range[1]: Input grayscale range	0~1023
Input UV Range	Input UV Range[0]: Input color value range	0~1023
	Input UV Range[1]: Input color value range	0~1023
Output Y Range	Output Y Range[0]: Output grayscale range	0~1023
	Output Y Range[1]: Output grayscale range	0~1023
Output UV Range	Output Y Range[0]: Output color value range	0~1023
	Output Y Range[1]: Output color value range	0~1023
Y Clip Level	Y Clip Level[0]: Clipping level for grayscale values	0~1023
	Y Clip Level[1]: Clipping level for grayscale values	0~1023
UV Clip Level	UV Clip Level[0]: Clipping level for color values	-512~511
	UV Clip Level[1]: Clipping level for color values	-512~511
Enable YC Proc	YCRT enable	0 1
Brightness	Overall brightness adjustment in the YUV domain	0~4095
Contrast	Global contrast adjustment in the YUV domain	-4096~4095
Saturation	Global saturation adjustment in the YUV domain	0~65535
Hue	Global hue adjustment in the YUV domain	-32768~32767

➢ Signal Range Mode:

- When "limit range" and "full range" are selected, the "input Y range", "input UV Range", "Output Y range", and "Output UV range" are in read-only state, displaying values corresponding to the selected mode.

- When "custom" is selected, the "input Y range", "input UV Range", "Output Y range", and "Output UV range" are in editable state, allowing users to define custom output numerical ranges.

3.27 DIS

3.27.1 Introduction

DIS (Digital Image Stabilization) involves calculating motion compensation vectors based on global movement to correct the position of the image, thereby eliminating or reducing the impact of random camera shakes on the image sequence, and achieving stable video images.

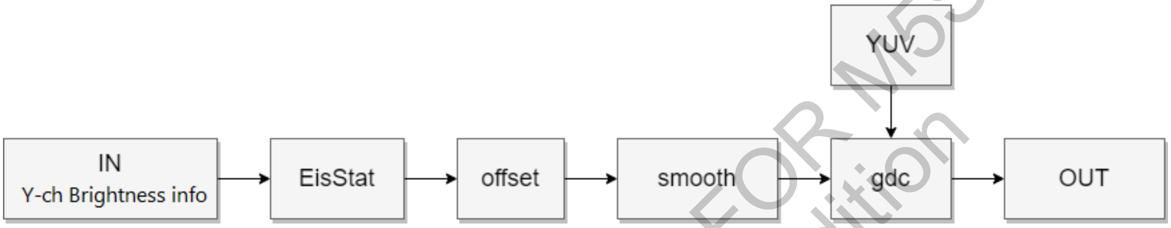
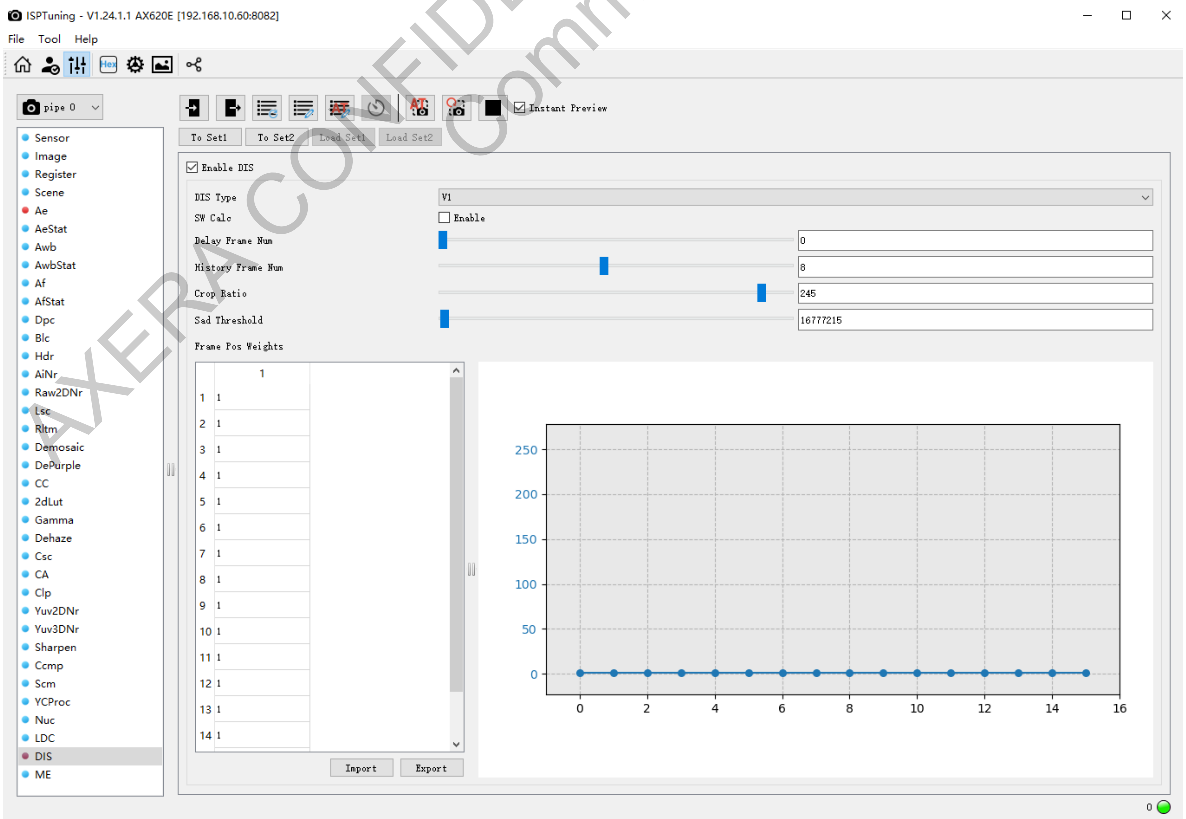


Figure 3-175 DIS Functional Principle

3.27.2 Interface



3.27.3 Parameter

Parameter	Description	Range
Enable DIS	DIS enable switch.	\
DIS Type	0: DIS_TYPE_V1	\
SW Calc	Software calibration enable switch	\
Delay Frame Num	Displays effect after a delay corresponding to the frame rate	0~15
History Frame Num	Number of historical frames involved in smoothing	1~16
Crop Ratio	Proportion of the image frame retained (crop_ratio/255.f)	127~255
Sad Threshold	Offset threshold	0~4294967295
Frame Pos Weights	Distribution of weight for historical frame positions; 0 corresponds to the current (t) frame, 1 to t-1 frame... 15 to t-15 frame, with a maximum configuration of weight distribution across 16 historical frames.	0~255

3.27.4 Debugging Steps

1. Select DIS Type V1.

2. Do not enable the SW Calc switch; use the default setting.

3. Set Delay Frame Num to 0 for immediate effect; delay is recommended to be set to 0 for instant effect.

4. Set History Frame Num to 8 for smooth performance without obvious jelly effect; the higher the value, the more pronounced the jelly effect.

5. Set Crop Ratio to 205~245, retaining 80%~95% of the image frame; the smaller the value, the less of the image frame is retained.

6. Sad Threshold has no effect; maintain the default value.

7. It is recommended to use equal Frame Pos Weights, i.e., all set to 1, for smoother stabilization convergence.

3.28 ME

3.28.1 Introduction

The ME module primarily functions as a statistical feature developed for Electronic Image Stabilization (EIS).

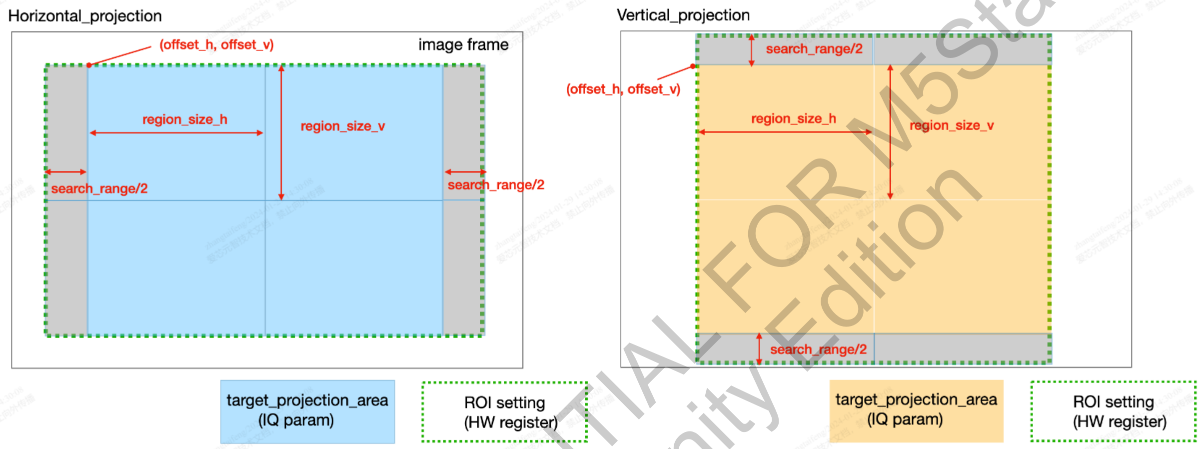
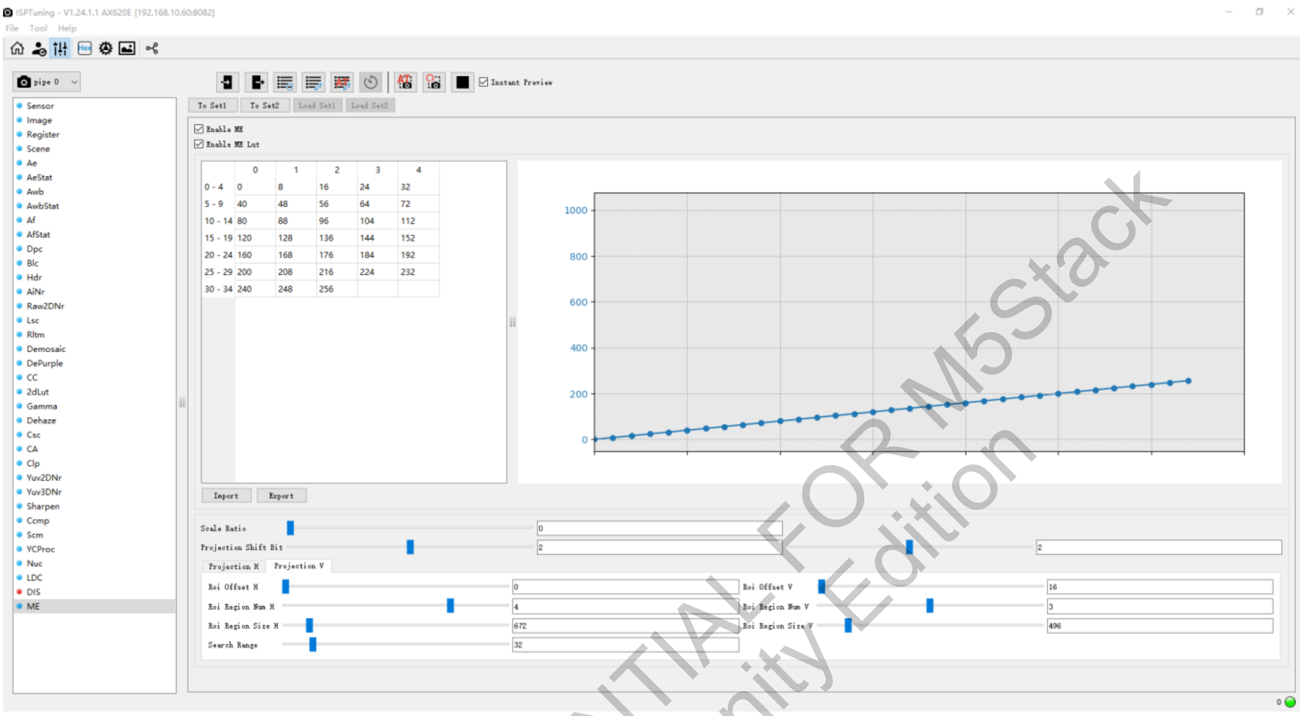


Figure 3-176 DIS Functional Principle

3.28.2 Interface



3.28.3 Parameter

Parameter	Description	Range
Enable ME	Switch to enable.	[0, 1]
Enable ME Lut	Brightens the Y channel of the image, making it easier to determine motion	[0, 1023]
Scale Ratio	Determines the scaling proportion; the smaller the value, the smaller the image size	[0, 2]
Projection Shift Bit	Prevents overflow in the horizontal/vertical direction, which can lead to inaccurate statistics after an overflow. If 4096 × grid_num = 1, then shiftbit = 4 If 4096 × grid_num = 2, then shiftbit = 2 If 4096 × grid_num = 1. If scale_ratio > 0, we can subtract “scale_ratio” from the numbers above. For example, input=4096, grid_num=2, and scale_ratio=2,	[0, 4]

	then shiftbit = 2 - 2 = 0	
Roi Offset H	The starting point coordinate of ROI	[0, 4096]
Roi Offset V		[0, 2160]
Roi Region Num H	Number of horizontal grid cells in the ROI being analyzed	[1, 5]
Roi Region Num V	Number of vertical grid cells in the ROI being analyzed	[1, 5]
Roi Region Size H	Width of each grid cell in the ROI	[256, 4096]
Roi Region Size V	Width of each grid cell in the ROI	[256, 4096]
Search Range	Width of the search area, with the actual area analyzed being the ROI plus the search area.	[0, 256]

3.28.4 Debugging Steps

1. Keep Enable ME Lut in default linear mode.

2. If the image noise is significant, consider increasing the Scale Ratio to use smaller images for statistical analysis of pixel phase differences.

3. Under normal circumstances, using the default parameters is sufficient.

3.29 Nuc

3.29.1 Introduction

The NUC module performs nonlinear correction on images in the Raw domain to prevent “ghosting” in the output images due to varying light response rates of sensor elements. It is primarily used for thermal imaging sensors.

The NUC module consists of two parts:

- Module Mode 0: An NUC adaptive calibration program used to obtain appropriate NUC configurations for the sensor.

- Module Mode 1: Outputs an image with two-point linear correction and fixed pattern noise correction (FPN integration).

3.29.2 Interface

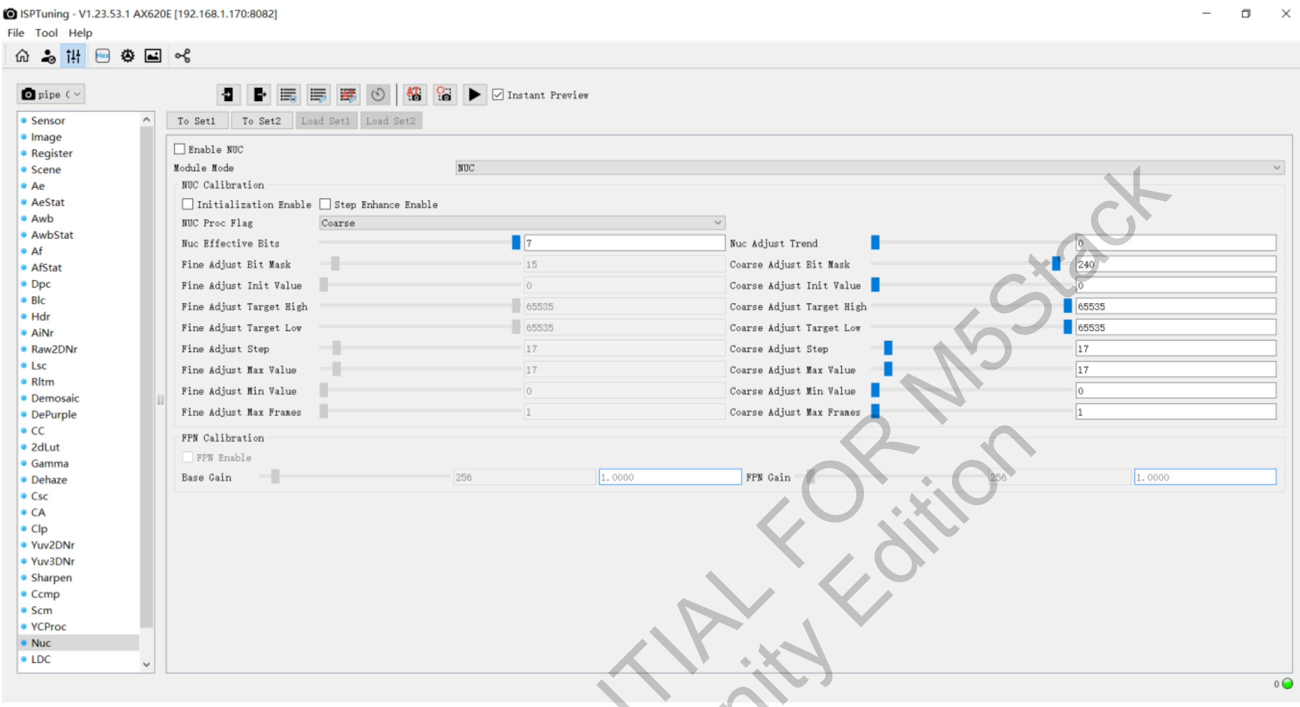


Figure 3-177 Nuc

3.29.3 Parameter

Parameter	Description	Range
Enable NUC	NUC enable switch.	\
Module Mode	NUC mode	\
	FPN mode	\
Initialization Enable	Initialization enable switch	\
Step Enhance Enable	Step enhancement switch	\
Nuc Proc Flag	Coarse (coarse adjustment)	\
	Fine (fine adjustment)	\
Nuc Effective Bits	NUC effective bit	0~7
Nuc Adjust Trend	NUC adjustment tendency	0~1
Fine/Coarse Adjust Bit Mask	Bit mask for fine/coarse adjustment	0~255
Fine/Coarse Adjust Init Value	Initial value for fine/coarse adjustment	0~255
Fine/Coarse Adjust Target High	High target value for fine/coarse adjustment	0~65535
Fine/Coarse Adjust Target Low	Low target value for fine/coarse adjustment	0~65535

Fine /CoarseAdjust Step	Adjustment step for fine/coarse tuning	0~255
Fine/Coarse Adjust Max Value	Maximum value for fine/coarse adjustment	0~255
Fine/Coarse Adjust Min Value	Minimum value for fine/coarse adjustment	0~255
Fine /CoarseAdjust Max Frames	Maximum frame rate for fine/coarse adjustment	0~65535
FPN Enable	FPN enable switch.	0~4095
Base Gain	Basic gain	0~4095

☞ Note: NUC mode and FPN Calibration mode are mutually exclusive. When the NUC Proc Flag is set to Fine, interfaces related to Coarse cannot be set.

3.29.4 Debugging Steps

NUC Debugging Steps

1. NUC correction requires setting the Nuc Proc Flag to determine coarse or fine adjustment, which correspond to different bit positions in the Sensor Nuc register. These bit positions can be set using the Fine/Coarse Adjust Bit Mask. During full range adjustment, any adjustment mode can be chosen, and the corresponding registers configured. For example, set all coarse adjustment-related registers according to full range and configure the c_bit_mask to 0xFF.

2. Configure the nuc_flag register to align the NUC adjustment trend with the sensor. If a larger nuc value results in a larger output, set nuc_adjust_trend to 0; otherwise, set it to 1.

3. Adjust the step register to quickly converge the nuc value.

4. Adjust the nuc_fcnt / nuc_ccnt registers to set the target iteration frame number.

5. Before starting the sensor nuc value correction, set cfg_1st_frame to 1 for initialization. If necessary, enable step_enhance_enable to improve convergence accuracy.

3.30 CLP

3.30.1 Introduction

The CLP (Color Palette) module is a color palette for thermal imaging sensors, providing you with specific palettes to colorize grayscale images output by thermal sensors.

3.30.2 Interface

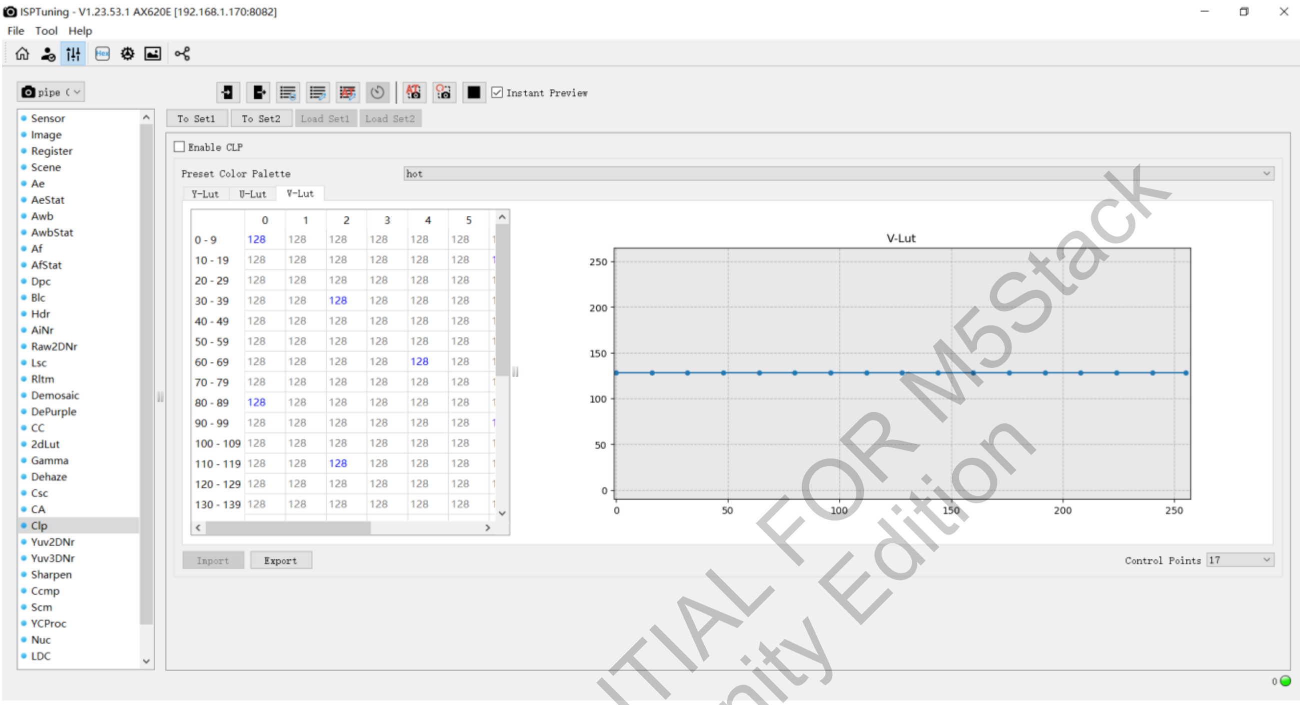


Figure 3-178 CLP Interface

3.30.3 Parameter

Parameter	Description	Range
Enable CLP	CLP enable switch.	0 1
Preset Color Palette	Preset color palette mode (hot/cool/jet/turbo/parula/autumn/winter/customized)	\
Y/U/V-Lut	Y/U/V 3-ch Lut	0~256

☞ The CLP is primarily used in thermal imaging modes and does not need to be enabled in non-thermal imaging modes.