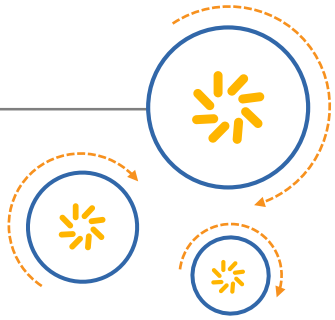
Qualcomm Technologies, Inc.



Local Tone Mapping

Feature Description

80-NN684-1 D

November 25, 2015

Qualcomm Technologies, Inc.
5775 Morehouse Drive
San Diego, CA 92121
U.S.A.

Revision history

Revision	Date	Description
A	April 2014	Initial release
B	June 2014	Update for tuning parameters
C	April 2015	Engineering update and conversion to word
D	November 2015	Update to Chromatix headers from 0x307 to 0x308

Contents

Figures

Tables

1 Introduction

1.1 Purpose

This document describes the use of the Local tone mapping (LTM) module in the Chromatix tool. It defines the purpose of the module, explains the concept of local tone mapping, defines the related parameters, and details the tuning procedure.

1.2 Conventions

Function declarations, function names, type declarations, attributes, and code samples appear in a different font, for example, `#include`.

Button and key names appear in bold font, for example, click **Save** or press **Enter**.

Shading indicates content that has been added or changed in this revision of the document.

1.3 Technical assistance

For assistance or clarification on information in this document, submit a case to Qualcomm Technologies, Inc. (QTI) at https://createpoint.qti.qualcomm.com/.

If you do not have access to the CDMATech Support website, register for access or send email to support.cdmatech@qti.qualcomm.com.

2 Problem Description and Purpose

Natural scenes have a wide dynamic range. Images captured by a camera system contain much information that is not obvious on display devices and not easily visible by viewers.

Original image

Ideal image

- In the original image, the bright area is already saturated and losing detail, and the dark area is too dark and invisible.
- In the ideal image, the bright area is suppressed and shows more detail, and the dark area is lightened up and has more visibility.

The ideal image is more pleasant and matched with the response of the human eye. There must be a more advanced image-processing block to achieve the ideal image from the original image.

3 Concept and Algorithm

3.1 LTM module in VFE

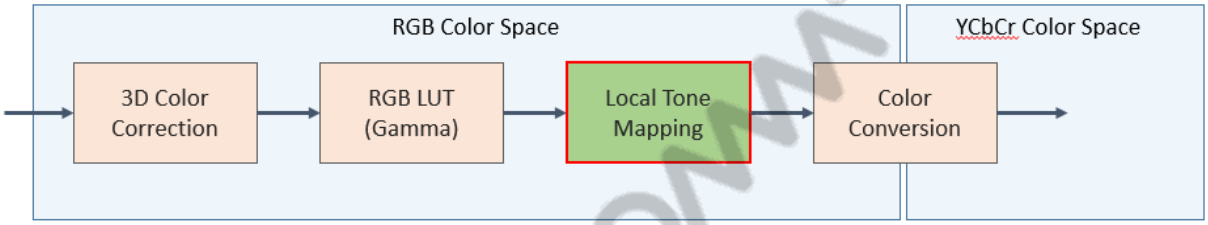


Figure 3-1 Location of local tone mapping module in video front end (VFE)

3.2 Approaches to tone mapping

Multiple tone mapping approaches can be used to bring details hidden in dark or bright regions to a more visible data range. The following approaches can be used:

- Global tone mapping (GTM) (or luma adaptation (LA) – Adjust all pixels based on their values by using same tone mapping curve
- LTM – Adjust pixels by using a different tone mapping curve and contrast enhancement based on local brightness

Although GTM can lighten up areas, it reduces contrast in normal light and bright regions. As a result, the image may look flattened.

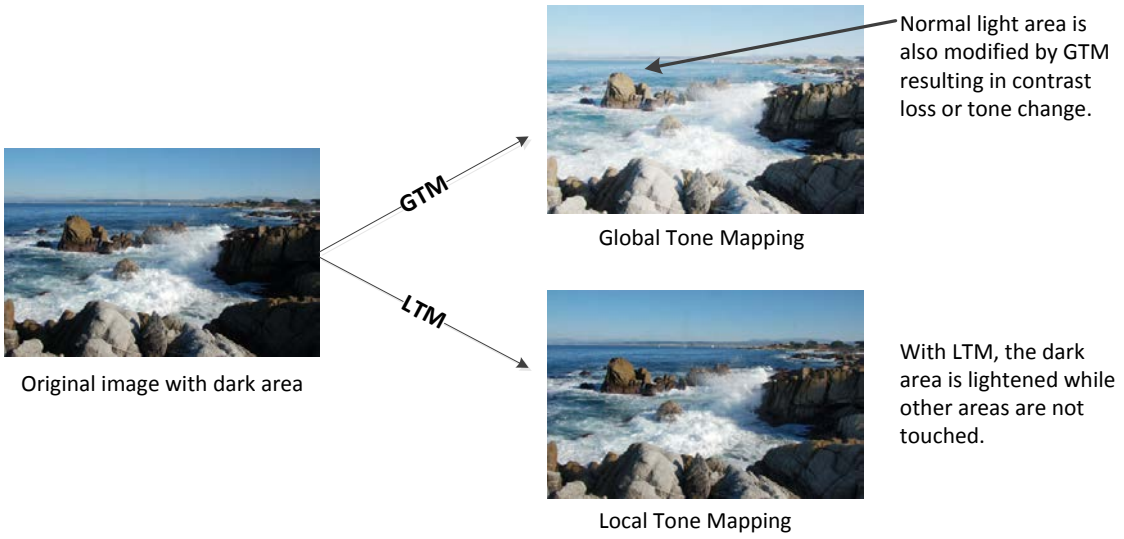


Figure 3-2 Comparison of global tone mapping and local tone mapping

3.3 Overview of the concept and algorithm

LTM is a single-frame single-exposure high dynamic range imaging solution. LTM does the following:

- Lightens up dark (low-tone) regions
- Leaves mid-tone regions unchanged
- Slightly suppresses bright (high-tone) regions
- Increases local contrast

Besides tone mapping, local contrast enhancement (LCE) is conducted to enhance details related to each pixel's neighboring average.

These approaches result in reduced global contrast while increasing local contrast. The more meaningful contents captured by the camera are brought into the limited dynamic range of the display device.

Before LTM **After LTM**

LTM does the following to improve the image and avoid side effects:

- Applies a bilateral filter to generate a nonlinear mask
- Avoids halo artifacts on the edges
- Uses an LTM curve set for local gain adjustment
- Uses a combination of LTM and LCE

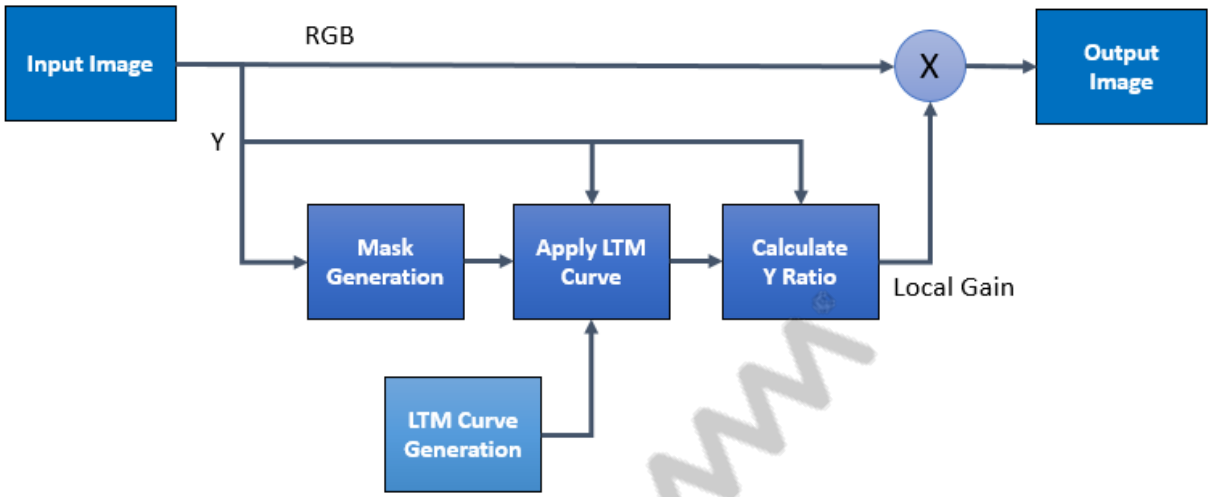


Figure 3-3 LTM block diagram

4 Tuning Parameters

NOTE: Numerous changes were made in this chapter.

4.1 Overview of LTM tuning parameters

Tuning parameters in the Chromatix header (version 0x308) include:

- Trigger control method
- Trigger point
- Core parameters for each light condition with:
  - Saturation and maximum gain control
  - Dark boost and highlight suppression control
  - Local tone strength and attenuation control
- Reserved parameters
  - RGB to Yp conversion
  - LTM fixed curve sets
  - Etc.

4.2 Parameters in the Chromatix header (version 0x308)

The LTM parameters appear as follows in the Chromatix header:

```
/* Local Tone Mapping */
{
 1, /* Enable */
 1, /* Control Enable */
 0, /* Control Method - 1 = Gain, 0 = Lux Index */
 /* Lowlight Trigger Points */
 { },
 /* Bright Light Trigger Points */
 { },
 /* Core Data */
 {
   /* Bright Light */
   {
       /* Sat_curve */
      { },
      16.000000f, /* Y Ratio Max */
```

```
      /* Unused parameters are collapsed. */
      1.000000f, /* Fixed Content Low */
      1.000000f, /* Fixed Content High */
      20, /* Global Tone Strength */
      /* Unused parameters are collapsed. */
      5, /* Local Tone Strength, use as 'low anchor point of AEC based
attenuation' */
      20, /* Local Tone Contrast, use as 'high anchor point of AEC based
attenuation'*/
      { },
      0.250000f, /* Strength Scale */
   },
   /* Normal Light */
   { },
   /* Lowlight */
   { },
 },
 /* Reserved */
 { }
},
```

Table 4-1 LTM_Type parameters

Parameter	Description	Range	Default
LTM_control_enable, control_LTM	Enable trigger control and LTM method	1 - Enable 1 – Gain, 0 – Lux index	1
LTM_low_light_trigger, LTM_bright_light_trigger	Trigger point and criteria for selecting proper LTM parameter among three light conditions		
chromatix_ltm_core_data [LTM_MAX_LIGHT]	Core data for each light condition	LTM_MAX_LIGHT = 3	
reservedData	Reserved data. We recommend that user does not change this data.		

Table 4-2 LTM_core_data parameters

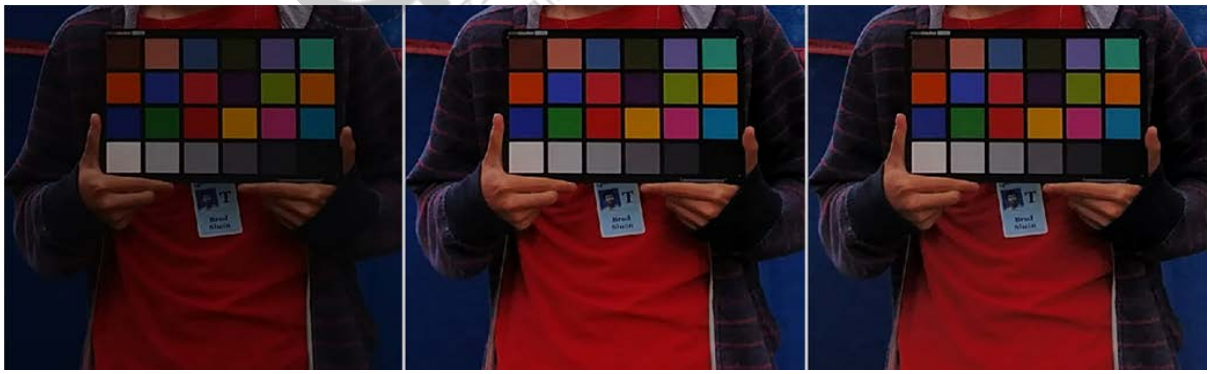
Parameter	Description	Range	Default
sat_curve[129]	Control to decrease the saturation caused by applying gains on the nonlinear domain. Increase left side of Sat Curve or decrease right side of Sat Curve to decrease saturation. This feature is available in MSM8996 or later chipset.	129LUT, [0, 8191]	
Y_ratio_max	Control the maximum gain applied on a pixel. Recommend using the default value.	0 to 64	16
fixed_content_low	Control the strength of boosting the dark area. Increase to boost dark region.	0.0 to 4.0	1.0

Parameter	Description	Range	Default
fixed_content_high	Control the strength of suppressing bright area. Increase to suppress highlight region.	0.0 to 4.0	1.0
nGlobalToneStrength	Control overall strength of LTM by adjusting several tables related to generating the LTM curve set. Increase to enhance the effect of LTM.	0 to 2048 Q8	256(1x) for normal 384(1.5x) for backlit
nLocalToneStrength, nLocalToneContrast	Control of LTM attenuation based on AEC (delta of exp_idx between frames). Recommend using the default value. If exposure oscillation is observed, reduce the parameter values.	0 to 2048	5 for low anchor 20 for high anchor

4.3 Saturation Curve

This parameter controls saturation. Decrease saturation caused by applying gains in the nonlinear domain.

- If the saturation curve is a straight line with a nonzero angle, e.g., 45 degrees, the LTM result is same as that without saturation control.
- To reduce saturation in a boosted area, the saturation curve must be bent as a downward concave curve on the right side and bent as an upward concave curve on the left side.
- Under low light conditions, reducing the saturation more can also reduce chroma noise more.



LTM off | **LTM on without Sat Curve tuning** | **LTM on with Sat Curve tuning**

4.4 Fixed Content Low and Fixed Content High

This parameter controls the strength of boosting up dark areas and suppressing bright areas, separately.

- Increase Fixed Content Low parameter to boost up dark areas
- Increase Fixed Content High parameter to suppress bright areas

Low: 1.0, High: 1.0 **Low: 2.0, High: 4.0**

4.5 Global Tone Strength

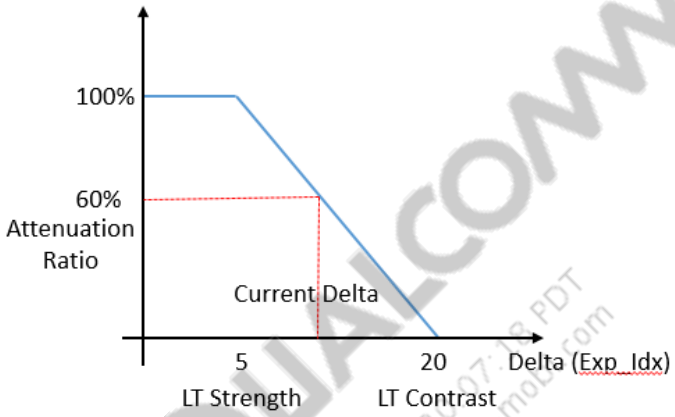
- Control the overall strength of LTM by adjusting several tables related to generating the LTM curve set
- Default value is 256 (1x) for normal scene, 384 (1.5x) for backlit scene
- Increase to enhance the effect of LTM

Strength: 128 (0.5x) **Strength: 256 (1.0x)** **Strength: 512 (2x)**

4.6 Local Tone Strength and Local Tone Contrast

These parameters control LTM attenuation based on the delta of exp_idx between frames. Local Tone Strength is used as the low anchor point. Local Tone Contrast is used as the high anchor point.

- Avoid oscillation or flicking during AE convergence by attenuating the strength of LTM when delta exp_idx is large. The attenuation ratio is multiplied to Global Tone Strength.
- Recommend using the default value. If exposure oscillation is observed, reduce the parameter values.



4.7 Reserved parameters

Parameters in the LTM reserved section of the Chromatix header include:

- RGB to Y conversion
- LTM fixed curve sets

It is recommended that you use the default values without manual tweaking and tuning.

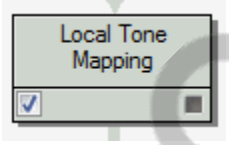
5 Tuning Procedure

5.1 Basic tuning procedure

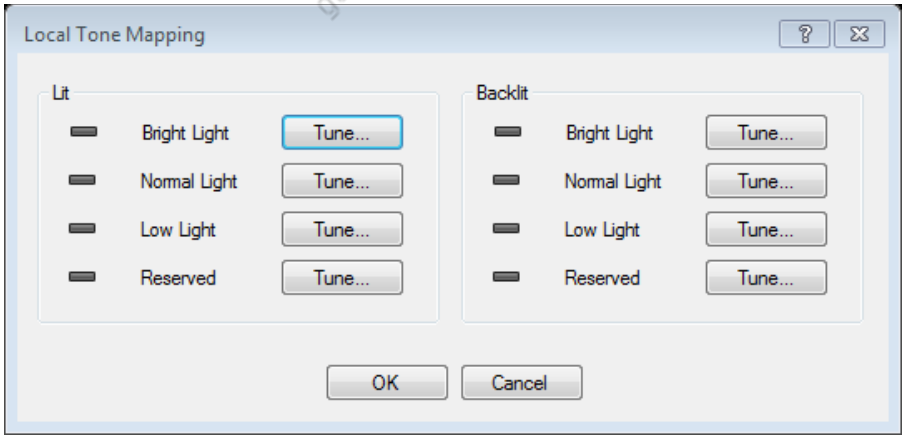
- Set all parameters to default values
- For each region, tune Global Tone Strength, Fixed Content Low and Fixed Content High
  - If users need stronger LTM effect, increase Global Tone Strength.
  - If users need more dark boost, increase Fixed Content Low.
  - If users need more highlight suppression, increase Fixed Content High.
  - Check if the noise level is acceptable as increasing dark boost.

5.2 Tuning LTM in the Chromatix tool

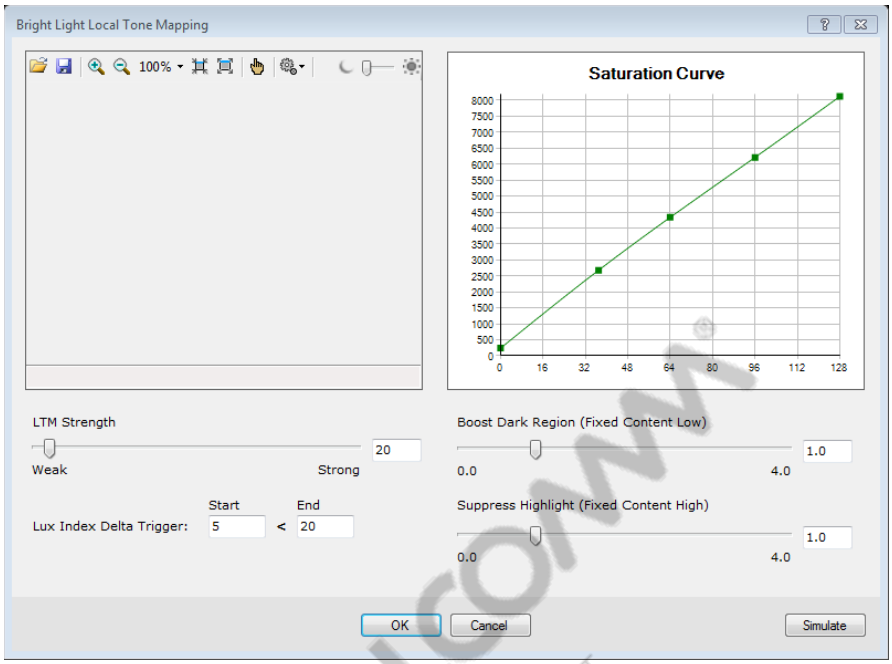
1. On the Chromatix Tuning tab, click the **Local Tone Mapping** block.



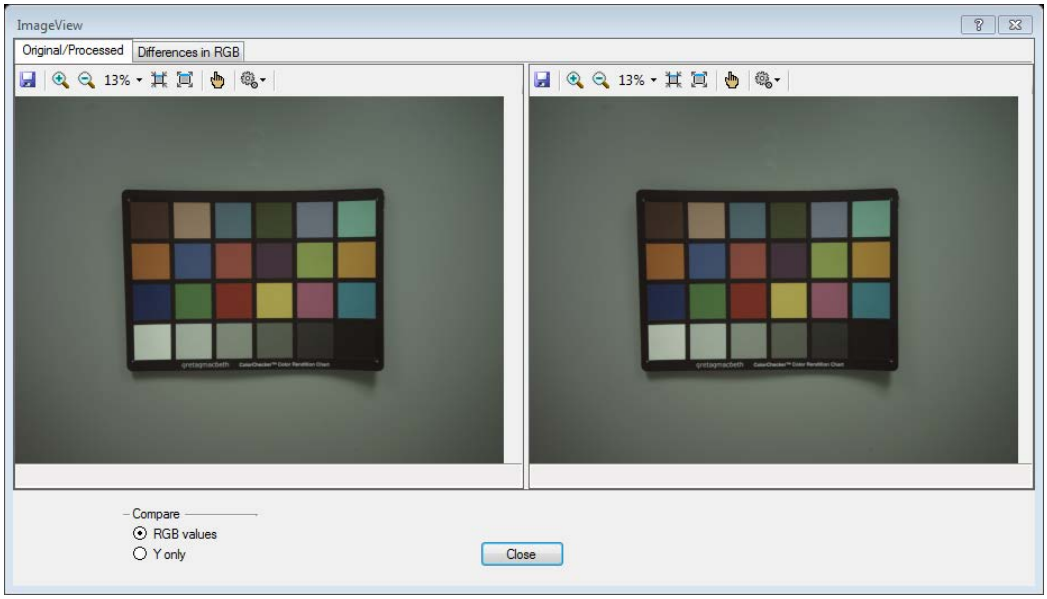
2. Click **Tune…** next to Bright Light in the Lit section.



3. In the LTM window, click the **Open** icon, choose an image, select the appropriate color temperature for the image, and click **OK**.



4. Move the **LTM Strength** slider to define the amount of tone mapping strength to apply to the overall image.
5. Move the **Boost Dark Region** slider to define the strength of the dark area boost.
   A larger value with the right direction results in more boosting in the dark region.
6. Move the **Suppress Highlight** slider to define the strength of bright area suppression.
   A larger value with the right direction results in more suppression of the bright region.
7. Adjust the **Saturation Curve** to control color saturation. You can add knee points by right-clicking the line. Refer to Section 6.3 for detailed instructions.
8. Click **Simulate** to apply the current settings to the loaded image. A preview image appears.



9. Click **Close** to dismiss the preview image.

10. Continue adjusting the slider until the preview image achieves the expected appearance.
11. Adjust the trigger values for attenuation, if needed.
12. Click **OK** to save the tuned LTM parameters.
13. Repeat steps 2 through 12 for the remaining light conditions. For the Backlit light condition, steps 8 through 10 do not apply because simulation is not available for backlit lighting scenarios. When complete, click **OK** to preserve the tuned LTM settings.

6 Scene-Based Tuning Guidelines

6.1 I observe more noise when boosting up dark areas with LTM. How can I improve the noise issue?

6.1.1 Tune ABF3 for dark area noise reduction

Using LTM to enhance local contrast may boost noise in dark regions, so avoid a strong LTM effect for indoor or low light scenarios. If you need to reduce noise in dark colors, use ABF3. Noise removal in ABF3 is level-based; therefore, use this module for noise reduction. The software automatically increases the noise removal strength in ABF3 noise profiles to dynamically reduce the noise in shadow regions of low-light images.

LTM enabled, with ABF3 modified | **LTM disabled, without ABF3 modified** | **LTM enabled, without ABF3 modified**

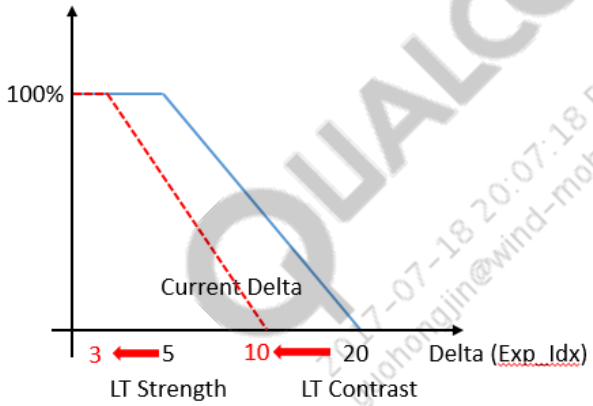
6.1.2 Tune 9x9 ASF block for dark areas

Use the 9x9 ASF module to control the strength of sharpness based on pixel intensity level as well as activity level. This module allows you to tune gain LUT to decrease the strength of sharpness for dark areas. See *MSM8996 Camera Tuning Guide*, 80-NK872-9, for 9x9 ASF tuning procedures.

6.2 I observe AE flickering and oscillation issues during AE convergence after enabling LTM. How can I improve this issue?

6.2.1 Tune the Local Tone Strength and Local Tone Contrast

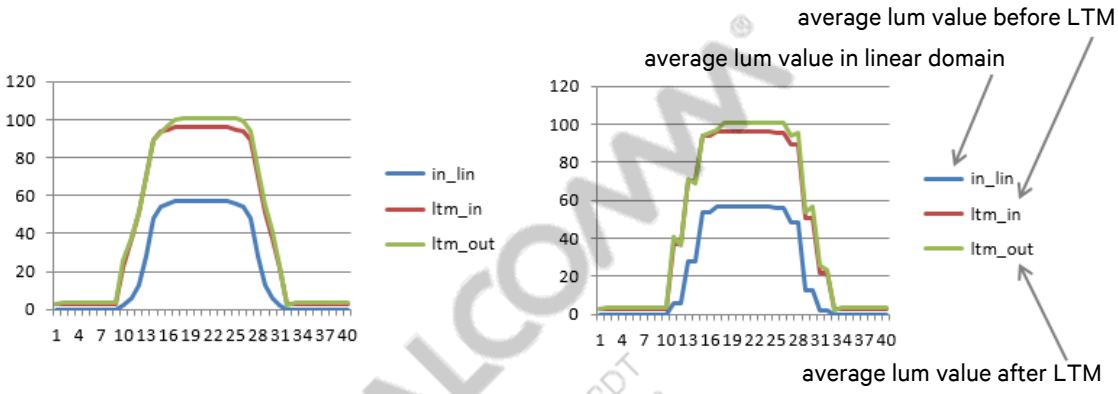
Reduce Local Tone Strength and Local Tone Contrast parameter values to attenuate the strength of LTM when AE converges with a large difference in the exposure index.



6.2.2 Check AEC aggressiveness and update timing

From the auto exposure adjustment (AEC) side, it is very important that the following occur:

- AEC converges smoothly
- AEC programming applied to the sensor must be on every frame. Otherwise (for example, programming the sensor on every other frame), unevenness may occur in video streams. It is especially critical for the low and regular frame rate scenario.



AEC programming on every frame AEC programming on every other frame

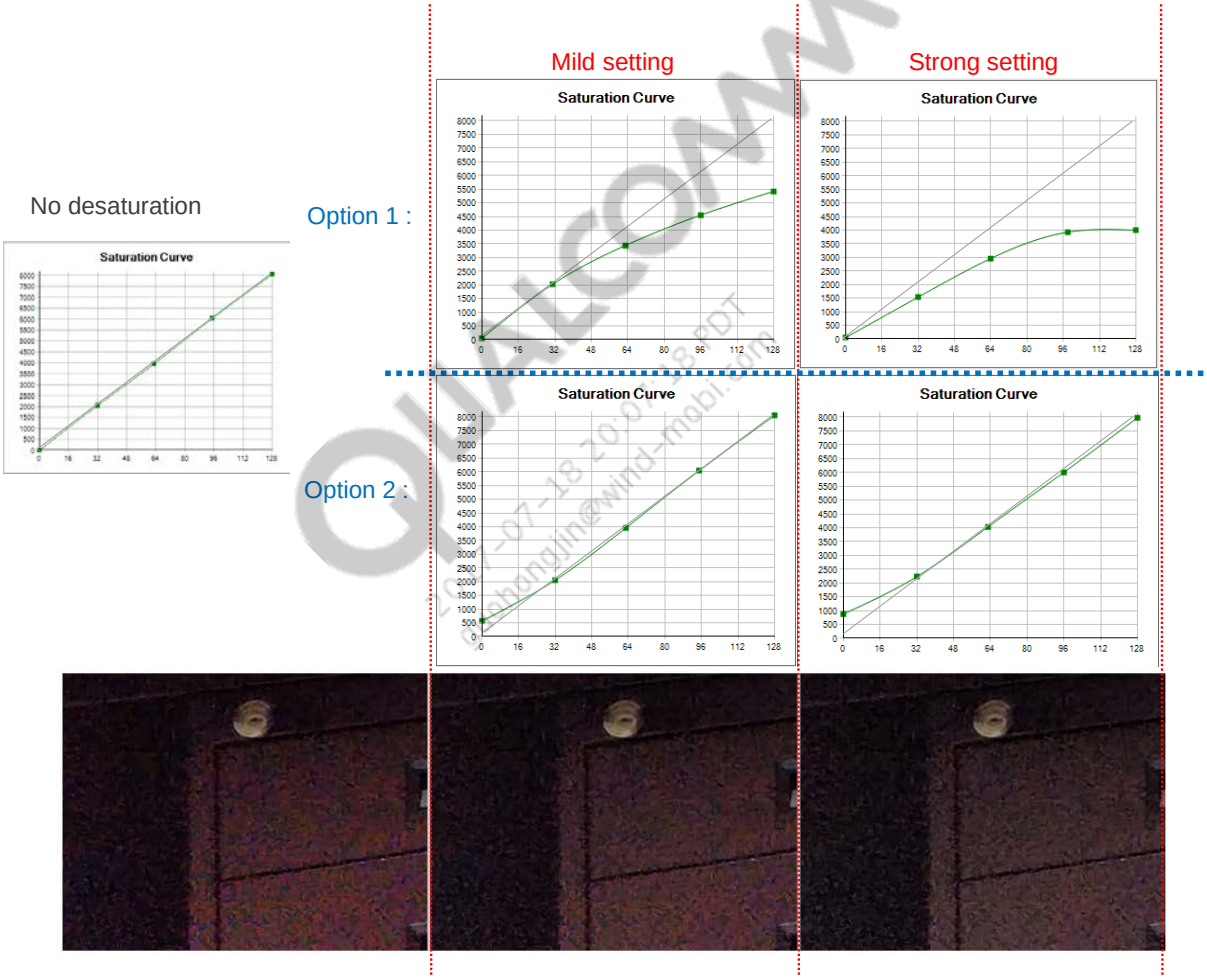
Figure 6-1 Simulated video stream with varying exposure

6.3 The saturation looks too high in a color object. How can I reduce color saturation?

Tune the Saturation Curve.

NOTE: The Saturation Curve feature is available in MSM8996 or later chipsets.

Bend the curve to be concave downward on the right side, as seen in Option 1 below, to decrease saturation. Increase the left side curve, like option 2 below, to get a similar effect.



A References

A.1 Related documents

Title	Number
Qualcomm Technologies, Inc.	
Chromatix 6 User Guide	80-NK872-1
MSM8996 Camera Tuning Guide	80-NK872-9

A.2 Acronyms and terms

Acronym or term	Definition
AEC	Auto exposure adjustrment
GTM	Global tone mapping
LA	Luma adaptation
LCE	Local contrast enhancement
LTM	Local tone mapping
VFE	Video front end