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Enabling Manual 3A Features

Application Note

80-NU119-1 A

November 19, 2014

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zhangqingshun@wind-mobile.com

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

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2017-07-18 20:09:03 PDT
zhangqingchun@winu-mobile.com

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Revision history

Revision	Date	Description
A	Nov 2014	Initial release

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1 Introduction

1.1 Purpose

This document lists out the guidelines for application developers to enable manual 3A features.

1.2 Conventions

Function declarations, function names, type declarations, and code samples appear in a different font, e.g., `#include`.

Code variables appear in angle brackets, e.g., `<number>`.

1.3 References

Reference documents are listed in Table 1-1. Reference documents that are no longer applicable are deleted from this table; therefore, reference numbers may not be sequential.

Table 1-1 Reference documents and standards

Ref.	Document	
Qualcomm Technologies		
Q1	*Application Note: Software Glossary for Customers*	CL93-V3077-1

1.4 Technical assistance

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

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

1.5 Acronyms

For definitions of terms and abbreviations, see [Q1].

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2 Manual 3A Features

Manual 3A is supported in non-ZSL mode with no other configuration settings like AE bracketing, HDR, Scene mode, brightness, flash, anti-banding and face priority, and Camcorder. The manual white balance and focus settings are applied in both non-ZSL preview and snapshot, however, the manual exposure settings take effect only in snapshot.

NOTE: These features are sensor dependent and would need changes in sensor driver code and exposure capabilities. The support range for exposure time, ISO, and focus depends upon the sensor and actuator capabilities.

The following are the Manual 3A features:

- Manual exposure control
- Manual white balance
- Manual focus

2.1 Manual exposure control

The following modes are supported in manual exposure control feature:

- ISO priority – User must provide ISO but exposure time is auto calculated by AEC.
- Exposure time priority – User must provide exposure time but ISO is auto calculated by AEC algorithm.
- User-provided ISO and exposure time – This mode is fully manual. Both ISO and exposure time directly taken from user input, but no auto calculation is involved.

NOTE: Settings are applied to snapshot only. Camera preview remains unchanged.

The following table explains the supported manual exposure modes queried from camera parameters:

Table 2-1 Camera parameters

Purpose	Camera parameter	Value/Result(s)
To check for supported manual exposure modes	manual-exposure-modes	Off, ISO-priority, exp-time-priority, user-setting – If any of the modes is not supported, corresponding entry is excluded in the query result. In such cases, it is suggested that the corresponding entry is removed in the application UI as well.

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2.1.1 ISO priority

In legacy/existing ISO feature, the user can set only discrete ISO values such as 200, 400, and 1600. However, in the new ISO-priority (or continuous ISO) mode, user is able to set any value between minimum ISO until the maximum ISO supported by the sensor.

Table 2-2 ISO priority parameters

Purpose	Parameter string	Value
Minimum ISO	min-iso	Depends on sensor capability
Maximum ISO	max-iso	Depends on sensor capability
Set continuous ISO	continuous-iso	Any integer within the supported range
Get preview ISO	cur-iso	Retrieves the ISO to be applied for preview. The ISO is used as a reference value for the user to set appropriate ISO in snapshot.

Application settings

1. Set legacy ISO mode to manual.
2. Set continuous ISO to appropriate value.
3. Set Exposure time to 0 (auto exposure).

Sample code

```
Int minISO = mParameters.getInt(“min-iso”);
Int maxISO = mParameters.getInt(“max-iso”);
Int userinput;
if( userinput >= minISO && userinput <= maxISO)
{
      mParameters.set(“iso”,“manual”);
      mParameters.setInt(“continuous-iso”, userinput);
      mParameters.set(“exposure-time”,”0”);
      mCameraDevice.setParameters(mParameters);
}
```

To switch back to legacy ISO mode, the legacy ISO parameter must be set to any of the discrete values or ISO_AUTO. In such a case, the continuous ISO, even if set, is ignored.

Sensor driver engineers to ensure that the capabilities for ISO are filled appropriately in the sensor driver structures from exposure table.

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Reference driver path

/vendor/qcom/proprietary/mm-camera/mm-camera2/media controller/modules/sensors/sensor_libs/imx135_lib.c

Sample code

```
static sensor_manual_exposure_info_t manual_exp_info = {
  .min_exposure_time = 10587,/*in nano sec = 1line*/
  .max_exposure_time = 693863262,/*in nano sec = FFFF lines*/
  .min_iso = 100,
  .max_iso = 800,
};
```

2.1.2 Exposure time priority

In this mode, the user can set any exposure time within the range supported by the sensor that is used. ISO is set to Auto in this mode.

Table 2-3 Exposure time priority parameters

Purpose	Parameter string	Value
Minimum exposure time	min-exposure-time	Depends on sensor capability
Maximum exposure time	max-exposure-time	Depends on sensor capability
Set exposure time	exposure-time	Any float value within the supported range. If exposure time is zero, Auto-exposure mode is enabled.
Get preview exposure time	cur-exposure-time	Retrieves the exposure time applied for preview. The exposure time is used as a reference value for the user to set appropriate exposure time in snapshot.

NOTE: All values are in milliseconds and are floating point numbers. If the user wants to set the exposure time in other modes like for example, 1/5 sec, the application automatically converts it into milliseconds when camera parameters are set.

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Application settings

1. Set appropriate exposure time in milliseconds.
2. Set ISO to Auto mode.

Sample code

```
        final String minExpTime = mParameters.get(“min-exposure-time”);
        final String maxExpTime = mParameters.get(“max-exposure-time”);
        double userIinput; //in millisec
        if (userIinput <= Double.parseDouble(maxExpTime) &&
               userIinput >= Double.parseDouble(minExpTime)) {
   mParameters.set(“exposure-time”, userIinput);
   mParameters.set(“iso”,”auto”);
   mCameraDevice.setParameters(mParameters);
        }
```

Sensor driver engineers to make sure that the capabilities of Exposure time is filled appropriately in the sensor driver structures as per sensor vendor recommendations. Some sensors also can support long exposure times that must be programmed to the respective sensor drivers. For simplicity and back ward compatibility a new variable, **use_long_exposure** in sensor_exp_info structure is introduced. The following is the sample code.

Reference driver path

/vendor/qcom/proprietary/mm-camera/mm-camera2/media controller/modules/sensors/sensor_libs/imx135_lib.c

Sample code

```
static sensor_manual_exposure_info_t manual_exp_info = {
  .min_exposure_time = 10587,/*in nano sec = 1line*/
  .max_exposure_time = 693863262,/*in nano sec = FFFF lines*/
  .min_iso = 100,
  .max_iso = 800,
};
static int32_t imx135_calculate_exposure(float real_gain,
                                         uint32_t line_count,
sensor_exposure_info_t* exp_info) {
  if (!exp_info) {
    return -1;
  }
  if(exp_info->use_long_exposure == 1) {
    exp_info->long_line_count = line_count;
  }
  else {
    exp_info->line_count = line_count & 0xFFFF;
  }
```


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2.1.3 User setting

In ISO priority mode, the ISO is manually set. However, the exposure time is auto-calculated. In the Exposure time priority mode, the exposure time is manually set but the ISO is in Auto mode.

In the User setting mode, both the ISO and exposure must be set manually. The camera parameters remain the same as in ISO priority and Exposure time priority modes.

Sample code

```
        final String minExpTime = mParameters.get(“min-exposure-time”);
        final String maxExpTime = mParameters.get(“max-exposure-time”);
        Int minISO = mParameters.getInt(“min-iso”);
        Int maxISO = mParameters.getInt(“max-iso”);
        Int userISOinput;
        double userExpTimeIinput; //in millisec
        if (userExpTimeIinput <= Double.parseDouble(maxExpTime) &&
               userExpTimeIinput >= Double.parseDouble(minExpTime) &&
               userISOinput >= minISO && userISOinput <= maxISO) {
mParameters.set(“exposure-time”, userIinput);
mParameters.set(“iso”,“manual”);
               mParameters.setInt(“continuous-iso”, userinput);
mCameraDevice.setParameters(mParameters);
        }
```

2.2 Manual white balance

The following modes are supported in manual white balance feature:

- Color temperature (CCT)
- RBGB gains

These settings are applied to preview and snapshot.

Application settings

1. Set White balance mode to Manual mode.
2. Set manual white balance type to CCT or RBGB
3. Set appropriate value in CCT or RBGB.

To turn off manual white balance (WB), change White balance mode to Auto or any other mode.

Table 2-4 Manual white balance parameters

Purpose	Parameter string	Value/Result
To check for supported manual white balance modes	manual-wb-modes	Off, color-temperature, rbgb-gains – The manual white balance for bayer sensors is by default supported. For YUV sensors, there is no support and hence the result to this query would be only “off”.

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Purpose	Parameter string	Value/Result
To set manual white balance type	manual-wb-type	0 for CCT mode, 1 for RBGB gain mode
To set manual white balance value	manual-wb-value	User input in CCT or RBGB gain mode – Valid input, input format, and supported range for each mode is explained in the next sections.

2.2.1 Color temperature

In the color temperature mode, the color temperature between minimum CCT and maximum CCT can be set depending on the camera capabilities.

Table 2-5 Color temperature camera parameters

Purpose	Camera parameter	Value
Minimum CCT	min-wb-cct	2000 (hardcoded in HAL)
Maximum CCT	max-wb-cct	8000 (hardcoded in HAL)
Get current WB in CCT	wb-manual-cct	Get current white balance in CCT

Sample code

```
Int minCCT = mParameters.getInt(“min-wb-cct”);
Int maxCCT = mParameters.getInt(“max-wb-cct”);
Int userinput = 5000;


If (userInput <= maxCCT && userInput >= minCCT) {
   mParameters.setWhiteBalance(“manual”);
   mParameters.set("manual-wb-type", 0);
               mParameters.set("manual-wb-value", userinput);
   mCameradevice.setparameters(mParameters);
}
```


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2.2.2 RGB gains

In RGB gains mode, user can set R, G, B gains as a set in the range 1.0 to 4.0 (hardcoded for now). Expected input format is “R_gain, G_gain, B_gain” as a string.

Table 2-6 RGB camera parameters

Purpose	Camera parameter	Value
Minimum gain	min-wb-gain	1.0 (hardcoded in HAL)
Maximum gain	max-wb-gain	4.0 (hardcoded in HAL)
Get current WB in RGB gain mode	manual-wb-gains	Get current RGB gains to be applied. Result is in the format “R_gain, G_gain, B_gain”, where each gain is a float value in the range mentioned in previous sections. For example, “2.5,3.0,1.0”

Sample code

```
String minGain = mParameters.get(“min-wb-gain”);
String maxGain = mParameters.get(“max-wb-gain”);
String userInput = “2.5,3.0,1.4”;

//parse user input and validate it with supported range
mParameters.setWhiteBalance(“manual”);
mParameters.set("manual-wb-type", 1);
mParameters.set("manual-wb-value", userinput);
mCameradevice.setparameters(mParameters);
```

NOTE: There is no one-to-one mapping between CCT and R, G, and B gains. Based on 2-D interpolation of R, G, and B weights, the current CCT value is calculated. So, it is expected that inputting the same displayed CCT value results in different gains and the final effect is different to that of the current preview.

NOTE: Typically R and B gains are higher than G gain. Inputting equal gain values in manual R, G, and B options results in green shade of preview/snapshot as there are two green channels in RGBG Bayer grid. It is assumed that the user knows the Bayer grid pattern and inputs the gains accordingly.

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2.3 Manual focus

The following modes are supported in the manual focus feature:

- Scale mode (0-100 scale), zero meaning near distance.
- Diopter-based – The diopter value in 1/meter (reciprocal of focal length) as a float value is provided.

Application settings

1. Set Focus mode to manual.
2. Set focus type to scale or diopter.
3. Set focus position.

To turn off manual focus, change the Focus mode to other modes such as Auto, CAF, etc.

Table 2-7 Manual focus camera parameters

Purpose	Camera parameter	Value/Result
To check for supported manual focus modes	manual-focus-modes	Off, scale-mode, diopter-mode
To set manual focus type	manual-focus-pos-type	2 for Scale mode, 3 for Diopter mode
To set manual focus position	manual-focus-position	User to input in Scale mode or Diopter mode. The Scale mode range is 0-100. It is queried from camera parameters as well. Input must be an integer. Range for Diopter mode depends on sensor and are queried from camera parameters. Input is a float value.

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zhangqingchun@windmobi.com

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2.3.1 Scale mode

Table 2-8 Scale mode camera parameters

Value	Camera parameter	Value
Minimum scale	min-focus-pos-ratio	0 (hardcoded in HAL)
Maximum scale	max-focus-pos-ratio	100 (hardcoded in HAL)
Get current focus position in scale mode	cur-focus-scale	Current focus position in the supported range. This can be used as a reference value for the user to know how much more lens needs to be moved.

Sample code

```
int minFocus = mParameters.getInt("min-focus-pos-ratio");
int maxFocus = mParameters.getInt("max-focus-pos-ratio");

mParameters.setFocusMode("manual");
mParameters.set("manual-focus-pos-type", 2);
mParameters.set("manual-focus-position", 70);
mCameraDevice.setParameters(mParameters);
```

2.3.2 Diopter mode

Table 2-9 Diopter mode camera parameters

Purpose	Camera parameter	Value
Minimum diopter	min-focus-pos-diopter	0 (hardcoded in HAL)
Maximum diopter	max-focus-pos-diopter	Sensor dependent
Get current focus position in Diopter mode	cur-focus-diopter	Current focus position in the supported range. This can be used as a reference value for the user to know how much more lens needs to be moved.

Sample code

```
String minFocusStr = mParameters.get("min-focus-pos-diopter");
String maxFocusStr = mParameters.get("max-focus-pos-diopter");
final float minFocusPos = Float.parseFloat(minFocusStr);
final float maxFocusPos = Float.parseFloat(maxFocusStr);

mParameters.setFocusMode("manual");
mParameters.set("manual-focus-pos-type", 3);
mParameters.set("manual-focus-position", 4.5);
mCameraDevice.setParameters(mParameters);
```


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Sensor driver engineers should fill the focus near end capability appropriately as per the maximum capability of the actuator inside the sensor driver structure. The fare end is considered to be INFINITY by default.

Reference driver path

/vendor/qcom/proprietary/mm-camera/mm-camera2/media controller/modules/sensors/sensor_libs/imx135_lib.c

Sample code

```
static sensor_lens_info_t default_lens_info = {
  .focal_length = 4.6,
  .pix_size = 1.4,
  .f_number = 2.65,
  .total_f_dist = 1.97,
  .hor_view_angle = 54.8,
  .ver_view_angle = 42.5,
  .near_end_distance = 10,/*in cm*/
};
```

2.4 Reference paths

Sample implementation of Manual 3A in application layer can be referenced at the following paths (based on the Android version):

- **Lollipop** – \packages\apps\SnapdragonCamera\src\com\android\camera\PhotoModule.java
- **Kitkat** – \packages\apps\Camera2\src\com\android\camera\PhotoModule.java

Core functions which do necessary settings (common in both Android versions):

```
UpdateManualExposureSettings()
UpdateManualWBSettings()
UpdateManualFocusSettings()
```

NOTE: In the reference implementation, all Manual 3A settings are turned off (get reset to default) when camera application is closed.

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Test example for manual exposure

Figure 2-1 gives an illustration of manual exposure feature tested with different options under same lighting conditions.

This set of snaps were taken using a tripod in dark lighting conditions with a sensor that supports long exposure times (up to 86 sec with QTI test sensor).

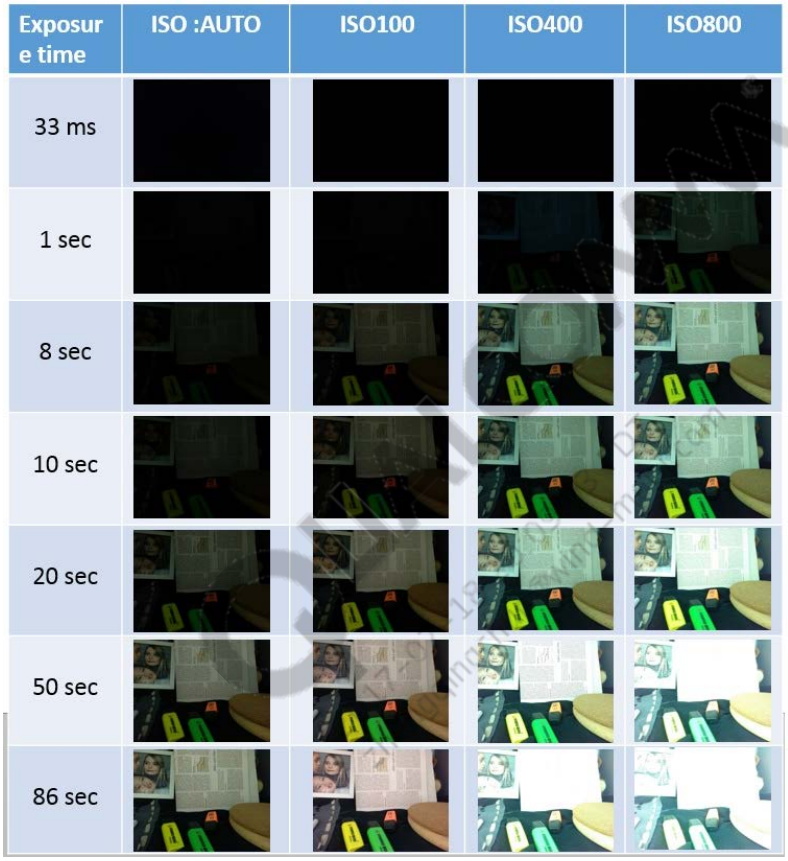

Figure 2-1 Illustration of manual exposure feature

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