
# Dual Camera Module Design and Production Guidelines

***80-Nxxxx-1 A***

***February 28, 2015***

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# Contents

# Tables

# Revision history

| Revision | Date | Description |
|---|---|---|
| A | Mar 3, 2015 | Initial release |
| | | |
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# 1 Introduction

## 1.1 Purpose

The purpose of this document is to provide the high level guidelines for design of dual camera assemblies for one of Qualcomm's dual camera-enabled MSM® processors. This document provides the high level design requirements and tolerances.

## 1.2 References

Reference documents, which may include Qualcomm documents, standards, and resources 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 Reference documents that are no longer applicable are deleted from this table; therefore, reference numbers may not be sequential.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*** | | |
| Q1 | *Application Note: Software Glossary for Customers* | CL93-V3077-1 |
| Q2 | Application Note: Dual Camera Module Design and Production Guidelines | 80-Nxxxx |
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## 1.3 Acronyms

For definitions of terms and abbreviations, see [Q1]. The following acronyms are used throughout this document.

- AF Auto-focus
- CFA Color filter array
- DDM Dense depth map
- DFoV Diagonal field of view
- DoF Depth of field
- ES Engineering samples
- FoV Field of view

- HFoV Horizontal field of view
- LCA Lateral chromatic aberration
- LSC Lens shading correction
- NF Near focus
- NV Nonvolatile
- NVM Nonvolatile memory
- SDM Sparse depth map
- VFE Video front-end

# 2 Dual Camera System Requirements

This chapter covers the requirements for dual camera assemblies. The purpose is to provide a top-level view of the key mechanical, optical, and electrical characteristics to efficiently align with the Qualcomm dual camera architecture. Aspects such as the assembly frame, shielding, and connector/flex are left to the module integrator and OEM, and are not relevant to the compatibility of the assembly to interface to the Qualcomm architecture, to the extent that dimensional stability is maintained from manufacture through final target device assembly.

Below three types of dual camera assemblies will be described. First are asymmetric dual camera assemblies that use a higher resolution primary sensor, and a lower resolution aux sensor that is used to generate the depth map. Second are the symmetric camera assemblies that use equivalent sensors and optics, either in a Bayer+Bayer, or Bayer+Mono color filter configurations. Finally are the camera assemblies with asymmetric optics in support of zoom capability.

### 2.1.1 Asymmetric dual camera assembly camera requirements

Figure 2 **錯誤! 找不到參照來源。**1 shows the top-level view of the asymmetric dual camera assembly with a 1/3” primary camera. The module is comprised of two cameras and an NVM to store calibration coefficients. The primary camera is AF with a bayer CFA.

A camera separation of 20mm is recommended for good depth mapping performance. If primary use case is iAF, the separation can be as little as 10mm to allow for a more compact assembly.

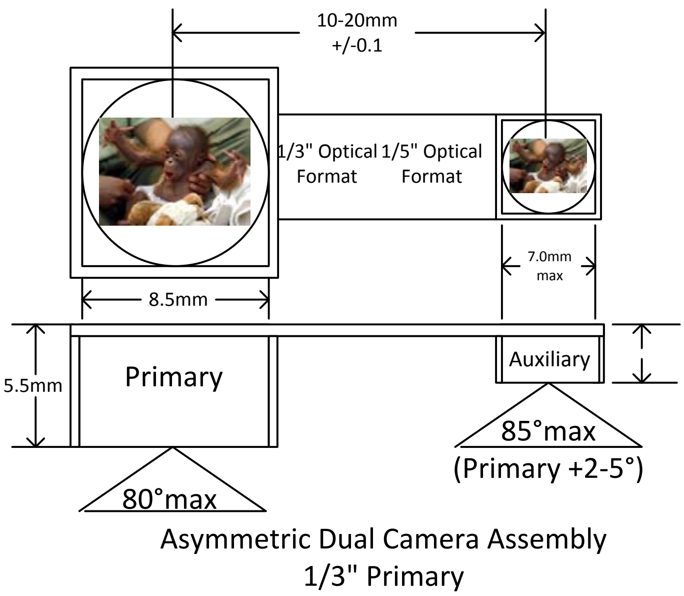


**Figure 2-1 Asymmetric dual camera module mechanical guidelines**

The optical requirements are such that the FOV for the auxiliary camera needs to take into account such factors as:

- Manufacturing tolerances of both cameras
- Change in FOV for primary camera over focus range
- Changes in FOV for both cameras over manufacturing and environment
- Overlap at minimum distance
- Maximum resolution loss desired at minimum working distance

The recommendation of 80° max for primary camera is based on typical optical designs to meet required module heights while not incurring excessive distortion, LCA, shading, or other aberrations. More aggressive designs could be considered, but will require engagement and study with Qualcomm.

Resolution requirements for the auxiliary camera to support DDM generation are proportional to primary camera resolution. Our analysis and empirical results indicate that the resolution of the auxiliary sensor can be reduced to ¼ (in both dimensions) of that of the main sensor without visible reduction of quality. For the 13Mpixel dual camera above, the aux sensor is operated in a 2x2 binning mode for an output of 800x600 pixels at 30fps. For the 21Mpixel dual camera, the aux sensor is operated at full resolution of 1600x1200 pixels at 24fps.

| Configuration | Primary | Auxiliary |
|---|---|---|
| 13MP+2MP | OV13850 | OV2685 |
| 21MP+2MP | IMX230 | OV2685 |

**Table 2-1  Asymmetric dual camera module sensor selections**

## 2.1.2  Symmetric dual camera assembly camera requirements

Figure 2 **錯誤! 找不到參照來源。**3 shows the top-level view of the symmetric dual camera assembly with 1/3” sensors. The module is comprised of two cameras and an NVM to store calibration coefficients. The primary camera is AF with a bayer CFA, the secondary camera is AF and may have either a mono or bayer sensor.

Camera separation recommendations are based on intended primary use case. A camera separation of 20mm is recommended for good depth mapping performance. If primary use case is iAF, the separation can be as little as 10mm. The fusion use case is best with minimum separation between the modules, this will still accommodate acceptable iAF performance.

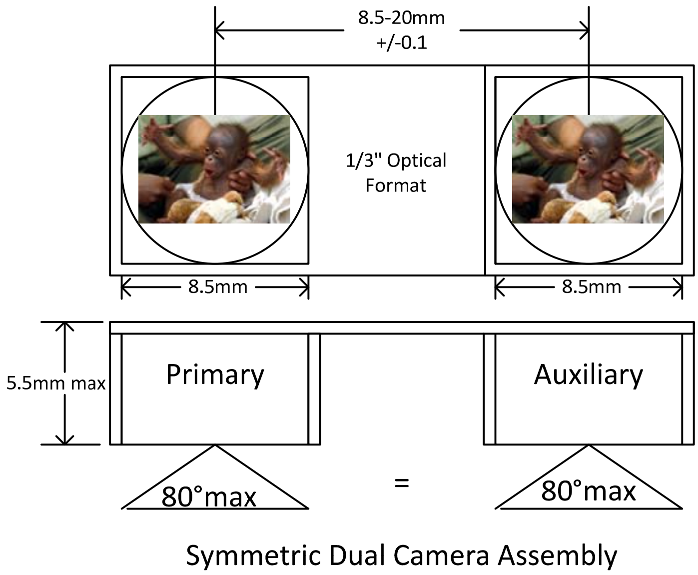


**Figure 2-3 Symmetric dual camera module mechanical guidelines**

The recommendation of 80° max for primary camera is based on typical optical designs to meet required module heights while not incurring excessive distortion, LCA, shading, or other aberrations. More aggressive designs could be considered, but will require engagement and study with Qualcomm.

| Configuration | Primary | Auxiliary |
|---|---|---|
| 13MP+13MP | OV13850 | OV13850/OV13851 |
| 8MP+8MP | OV8865 | OV8865 |

**Table 2-2 Symmetric dual camera module sensor selections**

### 2.1.3 Asymmetric optical dual camera assembly camera requirements

TBD

## 2.2 Module design section overview

Section 2.2 provides the alignment requirements for placing the two cameras on one board. It is very important to take measures when designing a dual camera assembly to stay within the camera alignment requirements presented in this section. Two sets of requirements are presented:

- Static tolerances – These tolerances are not expected to change after the module has been manufactured.
- Dynamic tolerances – These are changes in the camera alignment after the module has been manufactured.

### 2.2.1 Static tolerance requirements

The static tolerance requirements are made up of three translational and three rotational tolerances.

The module must be designed to meet the three translational and three rotational tolerances. These design tolerances will be covered in this section. Chapter **錯誤! 找不到參照來源。** covers how these tolerance limitations will be tested during manufacturing tests.

Figure 2-5 shows the ideal arrangement of the two cameras, where the sensor planes are ideally aligned with the camera lens optical axis. The two cameras are on the same plane, separated by distance B, and have no vertical shift along the X axis. They do not have any rotational differences as defined by yaw, pitch, and roll relative to each other.

Rotational tolerances for pitch, yaw, and tilt are 0.5° max. The translational tolerance for shift is +/-0.3mm.

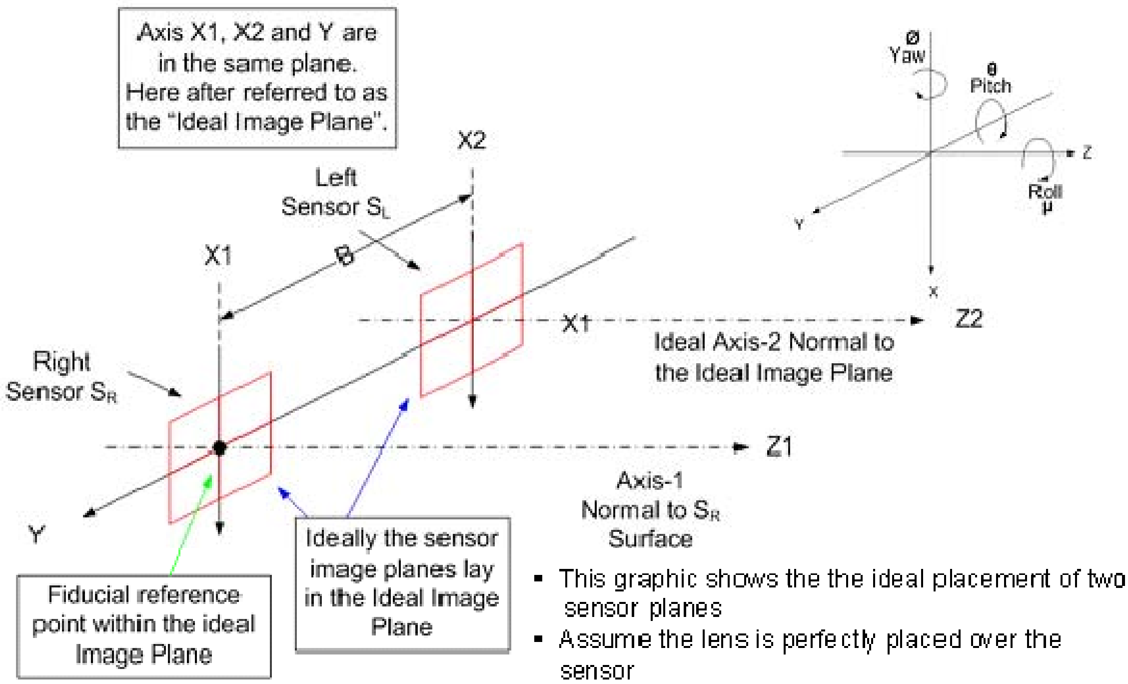


**Figure 2-5 Dual camera module alignment tolerances**

## 2.2.2 Dynamic tolerances requirements

All translational and rotational changes after 3D static calibration must be held to tight tolerances. During manufacturing, the calibration program (name TBD) is run for each module. This program will generate the correction matrix coefficients used to remove the static rotational differences between the two cameras, and an executable will be provided by Qualcomm.

After the calibration process is complete, it is possible that the camera can be altered in such a way to cause the camera alignment to change. These types of changes could be caused by:

- The module being bent after it has been dropped.
- The module being warped after being assembled in the handset.

It is essential that measures be taken to prevent changes like the above from happening.

Assuming the above types of changes are under control and held to near zero, the next most important factor to consider is the lens dynamic tilt in the yaw and pitch directions. For AF lenses, the optical axis of the lens barrel can change randomly. The causes of such random changes in the optical axis include:

- The lens barrel being moved during the AF operation
- Vibration
- Orientation of the camera, e.g., pointing up, down, horizontally, or any direction in between

The requirements for dynamic tilt are:

- The maximum allowable dynamic variations for both yaw and pitch of each separate camera is ±0.16° about its optical axis
- The maximum allowable pitch and yaw differences between the two cameras is ±0.20° when both lenses are focused at the same distance between 50 cm and infinity.

The translational tolerance for shift is +/-0.3mm.

### 2.2.3 Dual camera module electrical considerations

The module is comprised of two cameras and a Nonvolatile Memory (NVM) to store calibration coefficients.

Each camera module will have an independent $I^2C$ interface with the MSM. This allows identical AF controllers and sensors to be used in the 2 modules.

One camera module will be designated the master, and one camera module will be designated the slave. The master camera module will output a vertical frame synchronization signal. The slave camera module will have an input pin which is the vertical frame synchronization input. These 2 lines will typically be tied together either internal to the dual camera assembly, or can be connected at the board level.

Each camera's output interfaces to the MSM over MIPI CSI-2 lanes.

The NVM can be attached to the $I^2C$ line of either camera.

## 2.3 EEPROM memory map

TBD