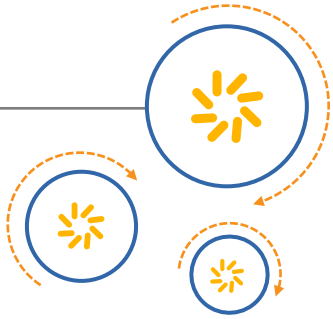
Qualcomm Technologies, Inc.



DragonBoard™ based on Qualcomm® Snapdragon™ processor

Application Note – Creating a Camera Mezzanine and Camera Flex Circuit for DragonBoard

September 2016

Questions or comments: https://www.96boards.org/DragonBoard410c/forum

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

LM80-P0436-53 Rev A

Revision history

Revision	Date	Description
A	September 20, 2016	Initial release

Contents

Figures

1 Introduction

1.1 Purpose

This application note provides instructions on how to design a mezzanine board and a camera flex circuit to permit a 5MP MIPI-CSI camera to be used with the DragonBoard 410c. The camera module and flex may also be used with other 96Boards products since it is compliant with the 96Boards Camera connector Addendum.

This document also outlines how to design a mezzanine board to convert from the CE High Speed connector to the Camera connectors.

1.2 Additional information

For additional information, go to https://www.96boards.org/db410c-getting-started/.

Other useful Documents

- 96Boards CE Specification http://www.96boards.org/ce-specification
- 96Boards Camera Addendum https://github.com/96boards/documentation/tree/master/Addenda
- 96 Boards Mezzanine Specification – Not published at the time of this document's publication.

2 Flex circuit for a camera module

This section provides design guidelines for the design of a 5MP camera module flex circuit as shown in Figure 2-1.

Figure 2-1 Camera Module Flex Circuit

This flex circuit is designed for use with a Sunny Optical module Q5V27B-201. See Figure 2-2.

Please use this information to contact Sunny Optical for module datasheets and procurement:

CoCo Wang 王柯科 Sales Dept.
宁波舜宇光电信息有限公司
Ningbo Sunny Opotech Co.,Ltd
地址：浙江省余姚市舜宇路66～68号
Address: No. 66-68, Shunyu Road, Yuyao, Zhejiang, China.
P.C.: 315400
Tel:: 0086-574-62553361 (8761)
Mob: 0086-13586612061 (662061)
Fax: 0086-574-62530812
www.sunnyoptical.com

Sunny Opotech NA
1798 Technology Dr. San Jose 95110
http://www.sunnyopotech.com/
info@sunnyopotech.com
Phone number: 408-329-9001 and ask for sales

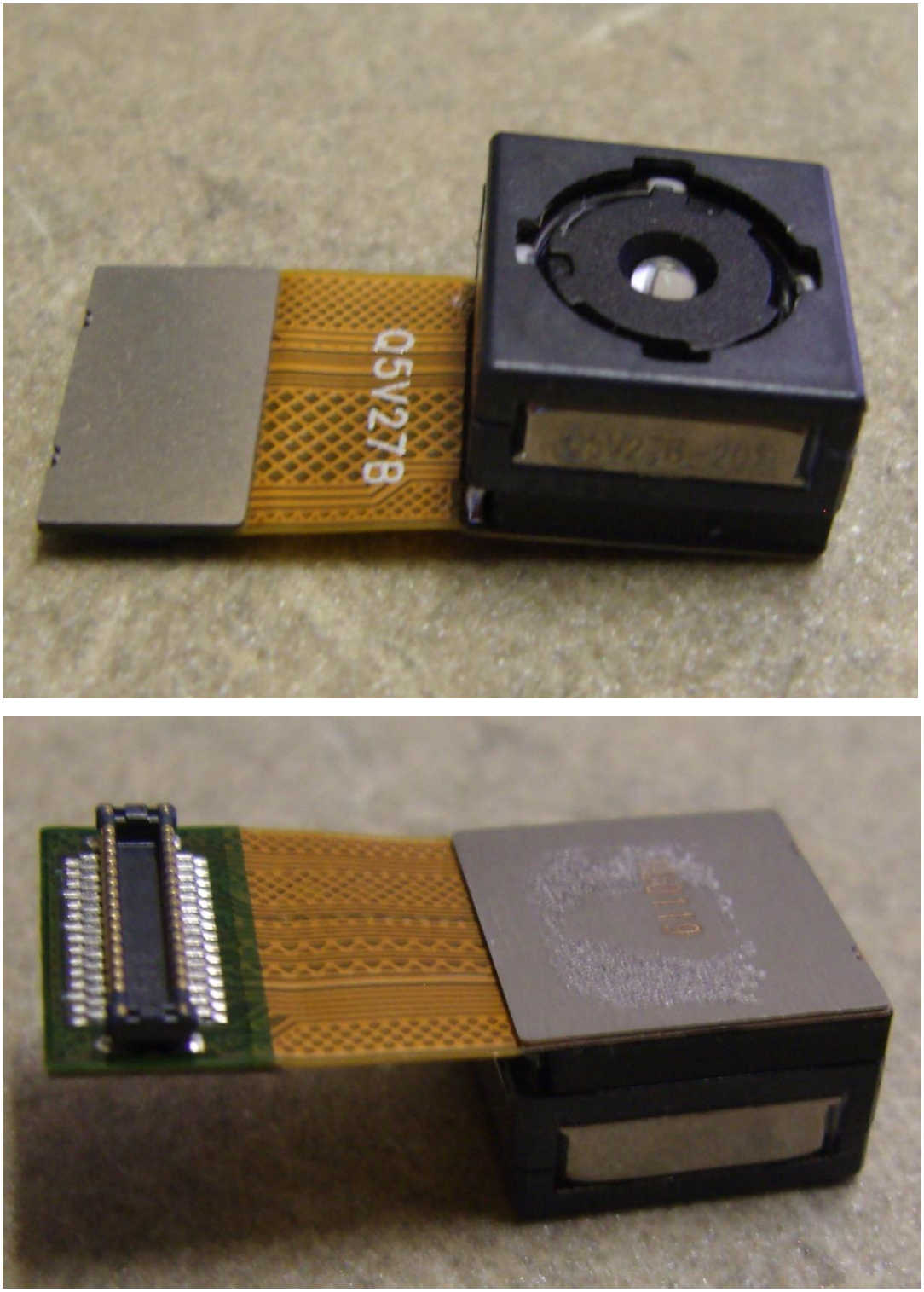
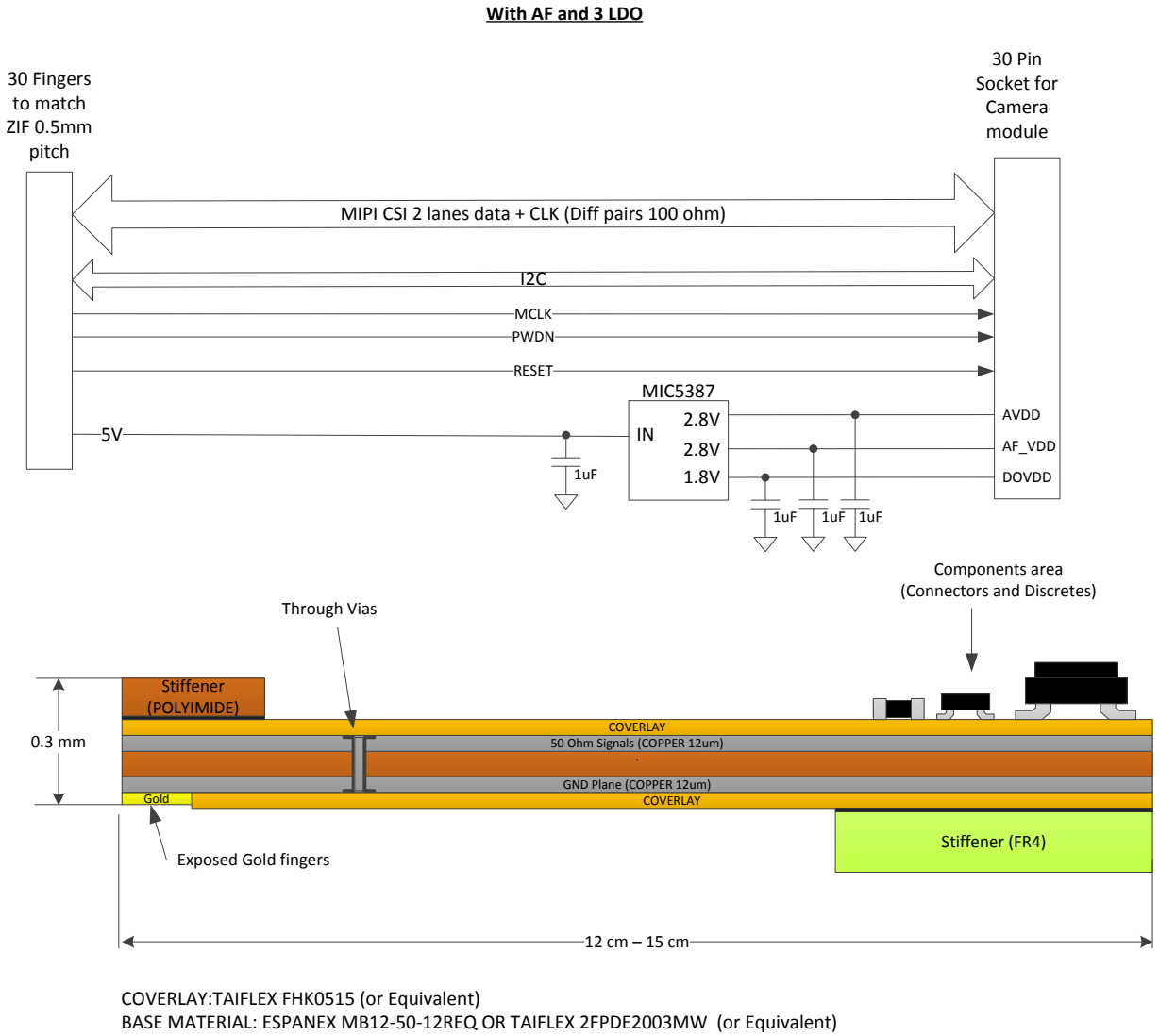


Figure 2-2 Sunny Optical module Q5V27B-201

2.1 High level overview

The block diagram (see Figure 2-3) shows an overview of the circuitry on the flex circuit. At a high level the flex circuit simply transmits the necessary signals from the 96Boards ZIF connector top the camera module. A regulator is placed onboard to provide the specific voltages required but the specific module selected.



COVERLAY:TAIFLEX FHK0515 (or Equivalent)
BASE MATERIAL: ESPANEX MB12-50-12REQ OR TAIFLEX 2FPDE2003MW (or Equivalent)

Figure 2-3 Flex Circuit Block Diagram

2.2 96Boards Pinout

Figure 2-4 shows the mechanical pin-out for the flex circuit. This is a 30-pin connector.

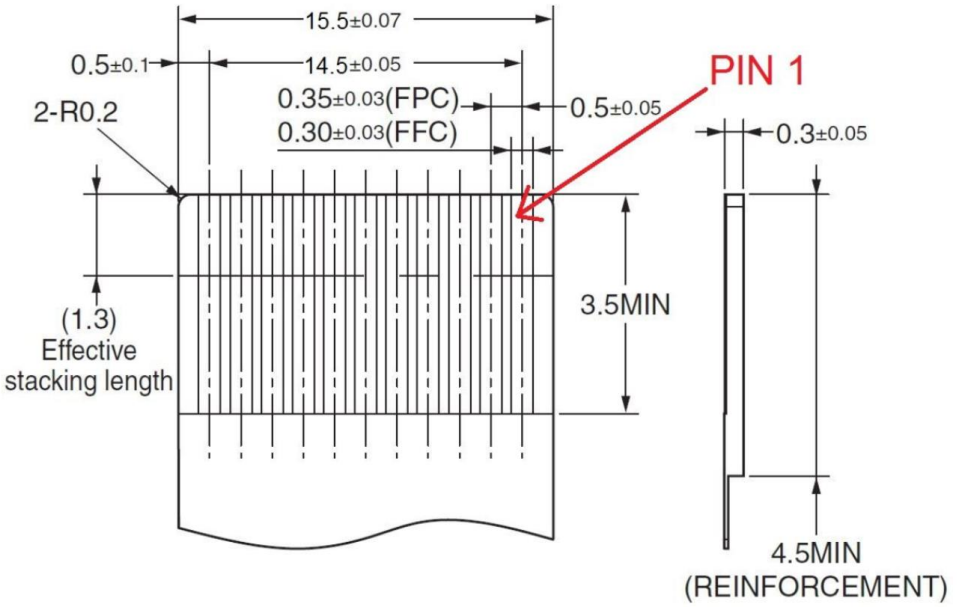


Figure 2-4 Circuit Pinout

2.3 Schematic

The detailed schematic for the flex circuit is shown in Figure 2-5.

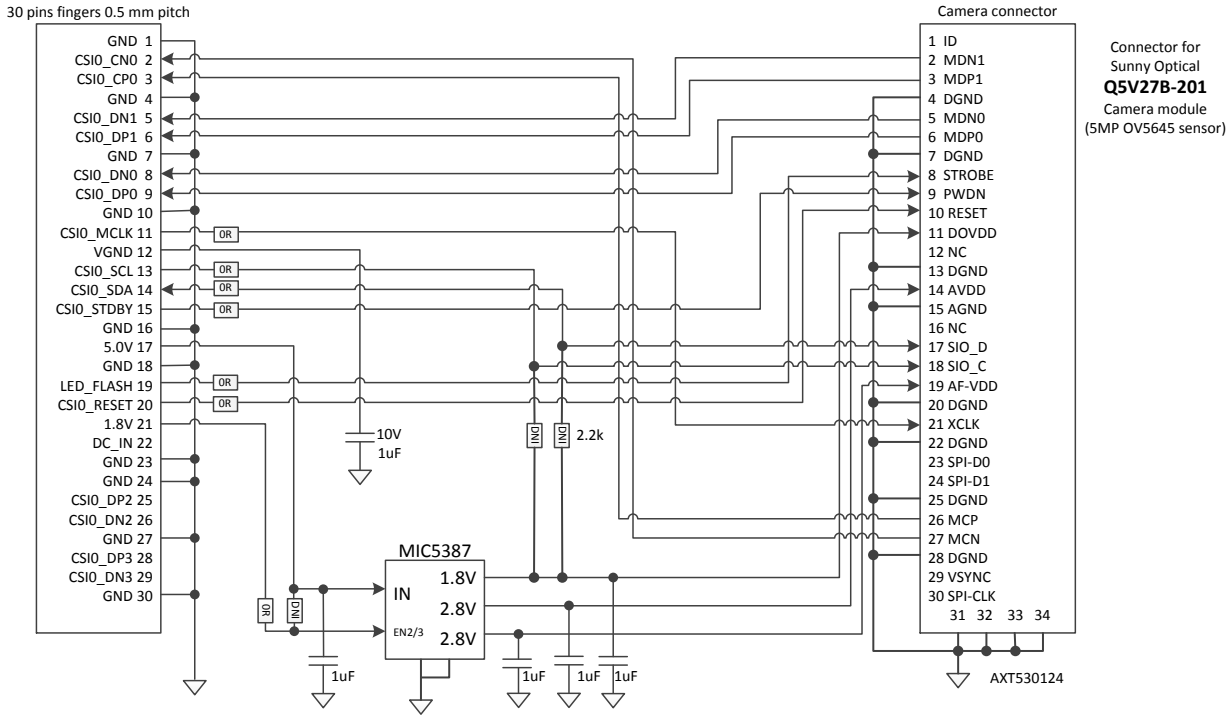
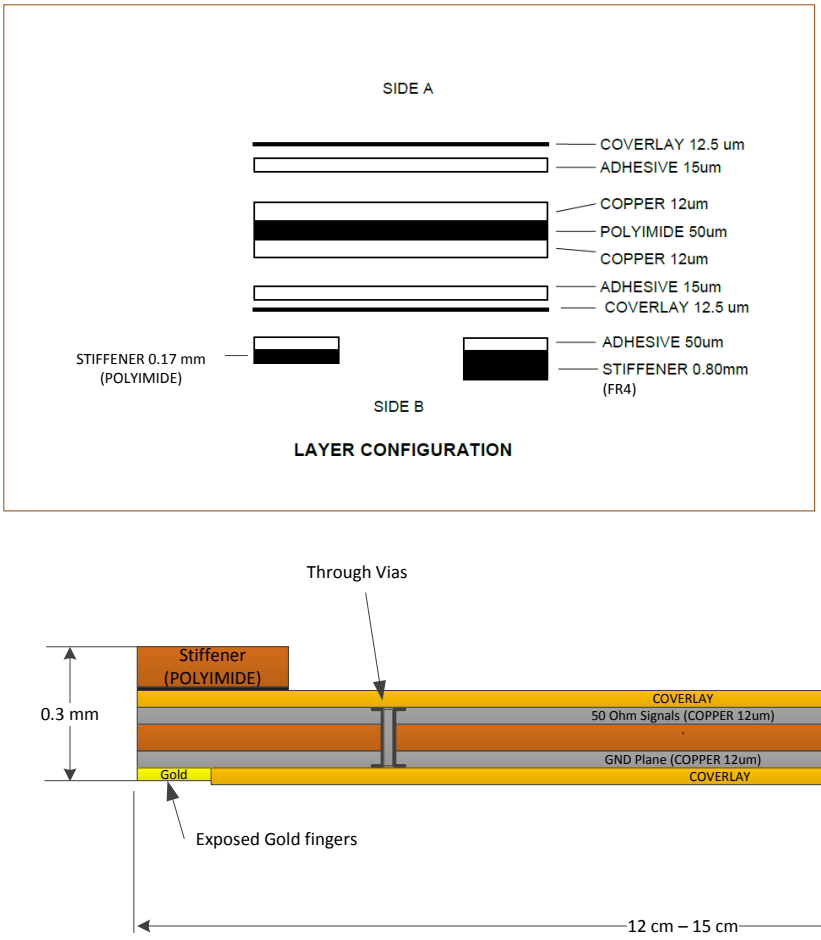


Figure 2-5 Detailed Circuit Schematic

The DC_IN signal is not used in this design. If a Camera module with a LED Flash is designed, DC_IN would be used to power the LED Flash, and GPIO_A to control the flash timing.

Please see Section 3.1.1 for a more detailed description of each of the signals.

2.4 Flex Circuit Stackup – Overview



COVERLAY:TAIFLEX FHK0515 (or Equivalent)
BASE MATERIAL: ESPANEX MB12-50-12REQ OR TAIFLEX 2FPDE2003MW (or Equivalent)

Figure 2-6 Circuit Stackup

2.5 Flex Circuit Stackup – Details

The two copper layers on the flex circuit form a micro-strip with carefully controlled impedance. Figure 2-7 shows the details of the micro-strip and the dimensions required to achieve a 50 Ohm micro-strip. The MIPI-CSI signals must be 100 Ohm differential pairs (50 Ohms for each trace). Changing any of the materials in the stackup will change the impedance calculations. Please consult with your flex circuit fabricator for details of the specific process and materials used. It may be necessary to change the track dimensions to achieve the differential impedance required.

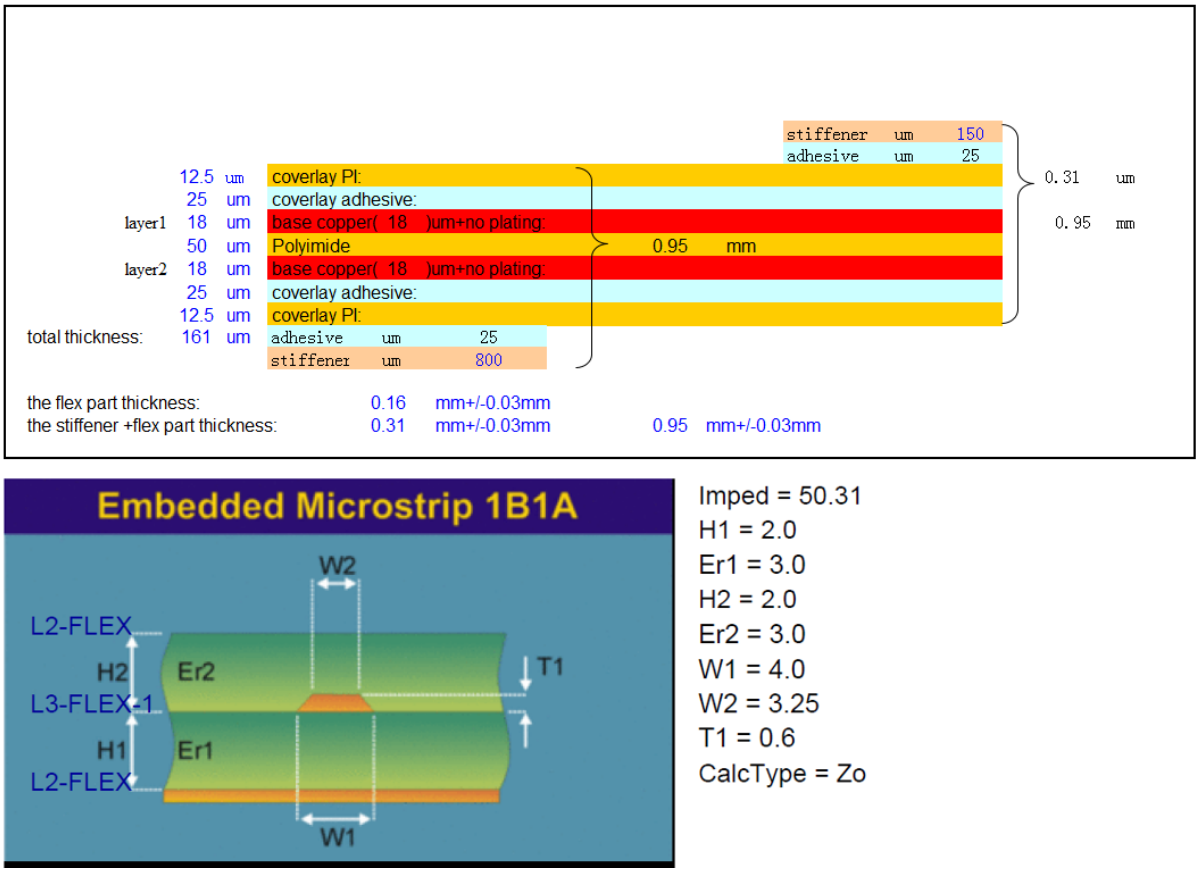


Figure 2-7 Circuit Stackup - Details

2.6 Design Considerations

In most user systems the user will wish to point the camera at the targets of interest. The user may also wish to mount the camera on a Gimbal to allow software to change the direction that the camera is pointing ‘on the fly’. Having a rigid camera mounting (i.e., mounting the camera module directly on the mezzanine board) prevents these use cases. However, the system designer may choose to directly mount the camera module on the Mezzanine board if the final application is well known.

The detailed electrical layout should consider the following rules:

Protect CSI signals from noisy signals (clocks, SMPS, etc.). Other comments and guidelines:

- 750 MHz clock rate; 1.5 GHz data rate
- Differential pairs, 100 Ω nominal, ±10%
- Total routing length < 305 mm
- Intra-pair length matching < 5 ps (0.67 mm) – Note 1
- Inter-pair length matching < 10 ps (1.3 mm) – Note 2
- Lane-to-lane trace spacing = 3x line width
- Spacing to all other signals = 4x line width

Note 1: The Intra-pair length match requirement (the difference in length between the P and the N signals in a pair) are cumulative for the entire system, there will be length match errors on the 410c board, on the mezzanine board, on the flex circuit, and in the camera module flex. Design of the camera flex circuit should provide the minimum possible error (ideally zero) since the total allowable error must be budgeted across 4 items.

Note 2: The Inter-pair length match requirement (the difference in length between the pairs of signals to a camera) are cumulative for the entire system, there will be length match errors on the 410c board, on the mezzanine board, on the flex circuit, and in the camera module flex. Design of the camera flex circuit should provide the minimum possible error (ideally zero) since the total error must be budgeted across 4 items.

In order to reduce EMI Ground guard trace at edges of the Flex are recommended.

Power trace widths should be wide enough to handle the expected current.

2.7 Bill of Materials

Item	Part Number	Supplier	Description	Ref Designator
1	Q5V27B-201	Sunny Optical	5MP CAMERA (OV5645) MODULE	
2	20-P4444	Panasonic	FPC, 5MP CAMERA (OV5645) ADAPTOR FOR 96BOARDS DRAGONBOARD	
3	C1005X7S1A105K	TDK	CAP,CHIP CERAMIC 1UF 10% X7S 10V ROHS	C1-C5
4	MIC5387-GMMYMT	Micrel Semiconductor	IC,VOLTAGE REGULATOR LDO 150MA 1.8-2.8V TRIPLE ROHS	U1
5	AXT530124	Panasonic	CONN,FPC 0.4MM PITCH STR SOCKET 30-POS ROHS	J1
6	ERJ2RKF1001X	Panasonic	RES 1K 100PPM 1% 0.063W 0402 ROHS	R2-R6
7	ERJ2GE0R00X	Panasonic	RES 0 200PPM 5% 0.063W 0402 ROHS	R1,R7

NOTE: The part numbers provided are representative only, equivalent parts from other suppliers are acceptable, with exception to the Sunny Camera module. The current Software only supports the Sunny module, however other modules may be supported in the future. Camera flex suppliers are encouraged to design with other modules, however it will be necessary to modify the SW to work with alternate camera modules.

3 Mezzanine Board Design

Figure 3-1 ST-Micro Robotics board

A mezzanine that supports a MIPI-CSI must make connections to both the High Speed connector (for the high speed MIPI signals), and to the Low Speed connector (for power and some controls). It is recommended that a camera mezzanine board design be full size (54x85mm).

3.1 Block Diagram

The MIPI-CSI connectors and the tracks to the High Speed connector will use very little of the PCB Area, hence other circuitry can be placed on the mezzanine board. The selection of additional circuitry to be placed on the Mezzanine board is up to the system designer.

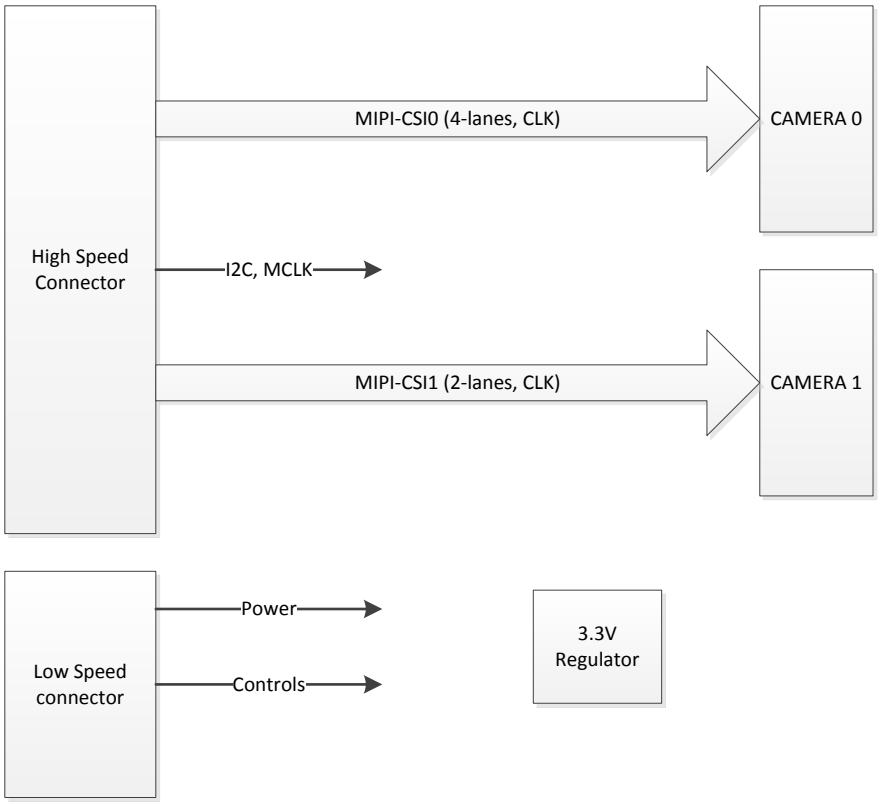


Figure 3-2 Block diagram

3.1.1 Signal Discussion

This section discusses some of the signals that are routed on the mezzanine card to the camera connectors and their special requirements.

GPIO-A is used to activate a LED Flash on the Camera Module, however many camera modules may not implement this functionality. Camera Mezzanine boards will likely have additional functionality on the board. GPIO-A is the only GPIO that is guaranteed to have interrupt capability on all 96Boards implementations (the 410c board has many GPIOs that can generate interrupts). The mezzanine board implementer may choose to make the connections to GPIO-A jumper selectable so that the interrupt capability can be used by the other circuitry on the board and only selected when a camera module with onboard Flash circuitry is connected.

GPIO-I, GPIO-J, GPIO-K, GPIO-L these GPIOs are used to reset the camera and place the camera in standby when not in use. The CE specification reserves these pins for operation of camera on mezzanine bioarts that implement camera connectors. Programmers should be aware that systems without cameras may use these pins for other functions. The mezzanine board implementer may choose to make the connections to these GPIOs jumper selectable so that they can be used by the other circuitry on the board and only selected when a camera module with onboard Flash circuitry is connected. The ‘default’ factory setting should have these GPIOs connected to the camera connectors.

DC_IN this signal provides power to the camera module, typically this would be used to power a LED Flash module. In most cases, camera modules that do not provide flash functionality will not use this power source. The connector specification limits the current on this pin to 200mA.

VGND (3.3V) This pin is a "Virtual Ground" it is required to provide electrical isolation between the MCLK and the SCL signals. A track must be run the full length of the camera module to ensure isolation of these two signals. Since the VGND track is used for isolation, a DC voltage on the track does affect the isolation properties. Hence this track is also used to provide 3.3V to the camera module. If a 3.3V regulator is available on the mezzanine board, then it is recommended that this pin be driven with 3.3VDC. If 3.3V is not available, then the pin may be left floating. Either way a Ceramic capacitor between VGND and GND is REQUIRED, on the camera mezzanine board. DO NOT connect VGND directly to GND.

GND All of the GND signals on all of the connectors should be connected directly to a Ground plane if at all possible. If this is not possible, a much of one plane in the area around the High Speed connector and the Camera connectors should be flooded with ground.

CSI Clock and Data pairs. These signals should all make direct connections between the High Speed connector and the Camera connectors. The impedance of the signals must be controlled as a 100 Ohm differential pair (50 Ohms impedance to the ground plane). It is recommended that a signal integrity simulation be done on these signals to ensure performance since it is extremely difficult to measure and confirm performance on a physical board. In addition to impedance control, the signals within a pair (inter-pair) must be length matched to within 0.67mm, and the pairs in a camera group (intra-pair) must be matched to within 1.3mm. The maximum inter-pair and intra-pair errors are cumulative across the system. Ideally there should be zero error on the mezzanine board. Finally the pairs must be separated from each other by 3x the signal spacing to reduce cross talk.

1.8V and 5V these signals are used to provide power to the camera module. The tracks between the Low Speed connector and the Camera connectors should be designed to carry at least 50mA on the 1.8V supply to each camera, and 200mA on the 5V supply to each camera.

3.2 Detailed Schematics

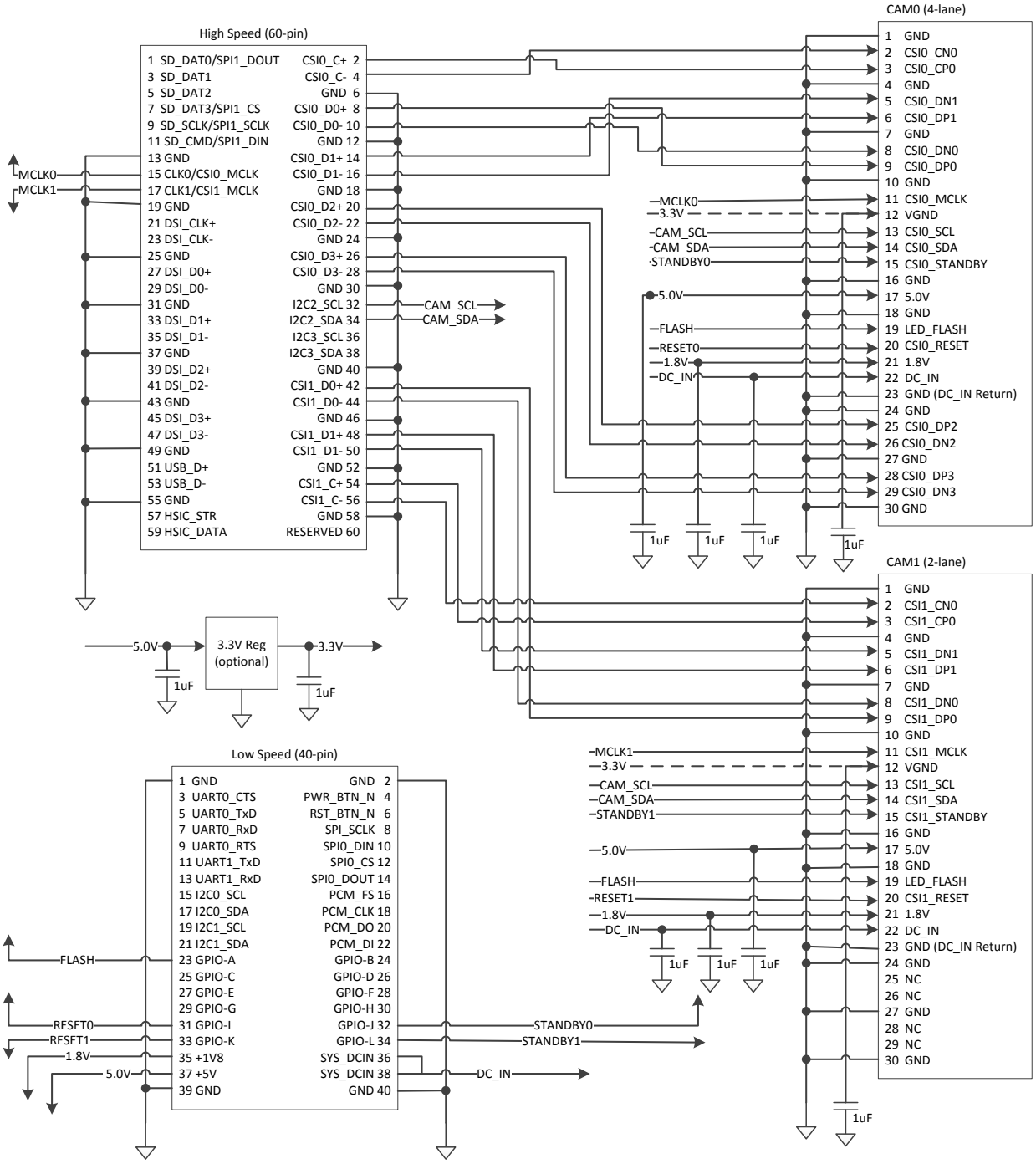


Figure 3-3 Detailed Schematics

3.3 Layout considerations

Connect all Grounds connected to a ground plane. Since impedance control is required, a 4-layer PCB is the minimum layer count expected for a mezzanine board that will be used for a Camera

mezzanine board. It may be possible to achieve these required impedances on a two-layer PCB, however it is up to the board designer to simulate and verify the design.

Signal Integrity simulations are strongly recommended before building any PCB. Most major PCB CAD tools have signal integrity simulation capabilities.

Signal Length matching is required, again, most major PCB CAD tools have this capability.

Protect CSI signals from noisy signals (clocks, SMPS, etc.). Other comments and guidelines:

- 750 MHz clock rate; 1.5 GHz data rate
- Differential pairs, 100 Ω nominal, ±10%
- Total routing length < 305 mm
- Intra-pair length matching < 5 ps (0.67 mm) – Note 1
- Inter-pair length matching < 10 ps (1.3 mm) – Note 2
- Lane-to-lane trace spacing = 3x line width
- Spacing to all other signals = 4x line width

  Note 1: The Intra-pair length match requirement (the difference in length between the P and the N signals in a pair) are cumulative for the entire system, there will be length match errors on the 410c board, on the mezzanine board, on the flex circuit, and in the camera module flex. Design of the camera mezzanine circuit should provide the minimum possible error (ideally zero) since the total error must be budgeted across 4 items.

  Note 2: The Inter-pair length match requirement (the difference in length between the pairs of signals to a camera) are cumulative for the entire system, there will be length match errors on the 410c board, on the mezzanine board, on the flex circuit, and in the camera module flex. Design of the camera mezzanine circuity should provide the minimum possible error (ideally zero) since the total error must be budgeted across 4 items. The lengths for the (5) signal pairs to camera 0 and the (3) signal pairs to camera 1 do not need to be the same.

The 96Boards Addendum compliant connectors are available from multiple manufacturers in both horizontal and vertical orientations. Pin 1 should be clearly marked on both the camera module and the mezzanine board to aid the user in correctly assembling the two components. The locations of the camera connector(s) are up to the systems designer, however it is recommended that the connectors be placed close to the High Speed connector to minimize the overall signal length.

EXHIBIT 1

PLEASE READ THIS LICENSE AGREEMENT ("AGREEMENT") CAREFULLY. THIS AGREEMENT IS A BINDING LEGAL AGREEMENT ENTERED INTO BY AND BETWEEN YOU (OR IF YOU ARE ENTERING INTO THIS AGREEMENT ON BEHALF OF AN ENTITY, THEN THE ENTITY THAT YOU REPRESENT) AND QUALCOMM TECHNOLOGIES, INC. ("QTI" "WE" "OUR" OR "US"). THIS IS THE AGREEMENT THAT APPLIES TO YOUR USE OF THE DESIGNATED AND/OR ATTACHED DOCUMENTATION AND ANY UPDATES OR IMPROVEMENTS THEREOF (COLLECTIVELY, "MATERIALS"). BY USING OR COMPLETING THE INSTALLATION OF THE MATERIALS, YOU ARE ACCEPTING THIS AGREEMENT AND YOU AGREE TO BE BOUND BY ITS TERMS AND CONDITIONS. IF YOU DO NOT AGREE TO THESE TERMS, QTI IS UNWILLING TO AND DOES NOT LICENSE THE MATERIALS TO YOU. IF YOU DO NOT AGREE TO THESE TERMS YOU MUST DISCONTINUE AND YOU MAY NOT USE THE MATERIALS OR RETAIN ANY COPIES OF THE MATERIALS. ANY USE OR POSSESSION OF THE MATERIALS BY YOU IS SUBJECT TO THE TERMS AND CONDITIONS SET FORTH IN THIS AGREEMENT.

1.1 **License.** Subject to the terms and conditions of this Agreement, including, without limitation, the restrictions, conditions, limitations and exclusions set forth in this Agreement, Qualcomm Technologies, Inc. ("QTI") hereby grants to you a nonexclusive, limited license under QTI's copyrights to use the attached Materials; and to reproduce and redistribute a reasonable number of copies of the Materials. You may not use Qualcomm Technologies or its affiliates or subsidiaries name, logo or trademarks; and copyright, trademark, patent and any other notices that appear on the Materials may not be removed or obscured. QTI shall be free to use suggestions, feedback or other information received from You, without obligation of any kind to You. QTI may immediately terminate this Agreement upon your breach. Upon termination of this Agreement, Sections 1.2-4 shall survive.

1.2 **Indemnification.** You agree to indemnify and hold harmless QTI and its officers, directors, employees and successors and assigns against any and all third party claims, demands, causes of action, losses, liabilities, damages, costs and expenses, incurred by QTI (including but not limited to costs of defense, investigation and reasonable attorney's fees) arising out of, resulting from or related to: (i) any breach of this Agreement by You; and (ii) your acts, omissions, products and services. If requested by QTI, You agree to defend QTI in connection with any third party claims, demands, or causes of action resulting from, arising out of or in connection with any of the foregoing.

1.3 **Ownership.** QTI (or its licensors) shall retain title and all ownership rights in and to the Materials and all copies thereof, and nothing herein shall be deemed to grant any right to You under any of QTI's or its affiliates' patents. You shall not subject the Materials to any third party license terms (e.g., open source license terms). You shall not use the Materials for the purpose of identifying or providing evidence to support any potential patent infringement claim against QTI, its affiliates, or any of QTI's or QTI's affiliates' suppliers and/or direct or indirect customers. QTI hereby reserves all rights not expressly granted herein.

1.4 **WARRANTY DISCLAIMER.** YOU EXPRESSLY ACKNOWLEDGE AND AGREE THAT THE USE OF THE MATERIALS IS AT YOUR SOLE RISK. THE MATERIALS AND TECHNICAL SUPPORT, IF ANY, ARE PROVIDED "AS IS" AND WITHOUT WARRANTY OF ANY KIND, WHETHER EXPRESS OR IMPLIED. QTI ITS LICENSORS AND AFFILIATES MAKE NO WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THE MATERIALS OR ANY OTHER INFORMATION OR DOCUMENTATION PROVIDED UNDER THIS AGREEMENT, INCLUDING BUT NOT LIMITED TO ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR AGAINST INFRINGEMENT, OR ANY EXPRESS OR IMPLIED WARRANTY ARISING OUT OF TRADE USAGE OR OUT OF A COURSE OF DEALING OR COURSE OF PERFORMANCE. NOTHING CONTAINED IN THIS AGREEMENT SHALL BE CONSTRUED AS (I) A WARRANTY OR REPRESENTATION BY QTI, ITS LICENSORS OR AFFILIATES AS TO THE VALIDITY OR SCOPE OF ANY PATENT, COPYRIGHT OR OTHER INTELLECTUAL PROPERTY RIGHT OR (II) A WARRANTY OR REPRESENTATION BY QTI THAT ANY MANUFACTURE OR USE WILL BE FREE FROM INFRINGEMENT OF PATENTS, COPYRIGHTS OR OTHER INTELLECTUAL PROPERTY RIGHTS OF OTHERS, AND IT SHALL BE THE SOLE RESPONSIBILITY OF YOU TO MAKE SUCH DETERMINATION AS IS NECESSARY WITH RESPECT TO THE ACQUISITION OF LICENSES UNDER PATENTS AND OTHER INTELLECTUAL PROPERTY OF THIRD PARTIES.

1.5 **LIMITATION OF LIABILITY.** IN NO EVENT SHALL QTI, QTI'S AFFILIATES OR ITS LICENSORS BE LIABLE TO YOU FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES, INCLUDING BUT NOT LIMITED TO ANY LOST PROFITS, LOST SAVINGS, OR OTHER INCIDENTAL DAMAGES, ARISING OUT OF THE USE OR INABILITY TO USE, OR THE DELIVERY OR FAILURE TO DELIVER, ANY OF THE MATERIALS, OR ANY BREACH OF ANY OBLIGATION UNDER THIS AGREEMENT, EVEN IF QTI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. THE FOREGOING LIMITATION OF LIABILITY SHALL REMAIN IN FULL FORCE AND EFFECT REGARDLESS OF WHETHER YOUR REMEDIES HEREUNDER ARE DETERMINED TO HAVE FAILED OF THEIR ESSENTIAL PURPOSE. THE ENTIRE LIABILITY OF QTI, QTI's AFFILIATES AND ITS LICENSORS, AND THE SOLE AND EXCLUSIVE REMEDY OF YOU, FOR ANY CLAIM OR CAUSE OF ACTION ARISING HEREUNDER (WHETHER IN CONTRACT, TORT, OR OTHERWISE) SHALL NOT EXCEED US$10.

2. **COMPLIANCE WITH LAWS; APPLICABLE LAW.** You agree to comply with all applicable local, international and national laws and regulations and with U.S. Export Administration Regulations, as they apply to the subject matter of this Agreement. This Agreement is governed by the laws of the State of California, excluding California's choice of law rules.

3. **CONTRACTING PARTIES.** If the Materials are downloaded on any computer owned by a corporation or other legal entity, then this Agreement is formed by and between QTI and such entity. The individual accepting the terms of this Agreement represents and warrants to QTI that they have the authority to bind such entity to the terms and conditions of this Agreement.

4. **MISCELLANEOUS PROVISIONS.** This Agreement, together with all exhibits attached hereto, which are incorporated herein by this reference, constitutes the entire agreement between QTI and You and supersedes all prior negotiations, representations and agreements between the parties with respect to the subject matter hereof. No addition or modification of this Agreement shall be effective unless made in writing and signed by the respective representatives of QTI and You. The restrictions, limitations, exclusions and conditions set forth in this Agreement shall apply even if QTI or any of its affiliates becomes aware of or fails to act in a manner to address any violation or failure to comply therewith. You hereby acknowledge and agree that the restrictions, limitations, conditions and exclusions imposed in this Agreement on the rights granted in this Agreement are not a derogation of the benefits of such rights. You further acknowledges that, in the absence of such restrictions, limitations, conditions and exclusions, QTI would not have entered into this Agreement with You. Each party shall be responsible for and shall bear its own expenses in connection with this Agreement. If any of the provisions of this Agreement are determined to be invalid, illegal, or otherwise unenforceable, the remaining provisions shall remain in full force and effect. This Agreement is entered into solely in the English language, and if for any reason any other language version is prepared by any party, it shall be solely for convenience and the English version shall govern and control all aspects. If You are located in the province of Quebec, Canada, the following applies: The Parties hereby confirm they have requested this Agreement and all related documents be prepared in English.