

# People Identification System Based on Stereoscopic Computer Vision

Cezar Menezes and Cleber Picolo

## Electronic Design of a Custom Camera Mezzanine

### OBJECTIVES

This electronic project has the following main objectives:

- **Electronic Modeling** (Schematics / Layout) of a camera mezzanine for interfacing two MIPI-CSI OV5645 modules
- **Manufacturing Cost Estimation** (FOB prices)
- **Analysis of similar hardware reference designs** (MIPI Adapters) available on the market (AISTARVISION e D3 ENGINEERING).

The hardware reference designs studied have many similarities between them. The main difference is related to the choice of the **I2C** interface used for the second camera (**MIPI-CSI1**). Although the “**DragonBoard 410c Hardware Manual**” document states that the **I2C** interface for the second camera should be the **I2C3**, each manufacturer has adopted its own choice (this selection is usually available on Mezzanine boards via jumpers or configuration headers, and must be compatible to the modified **Debian** drivers or images).

The current version of this project adopts the **I2C2** interface for both cameras (based on the current version of MIPI ADAPTER 2.0 from the manufacturer AISTARVISION).

The D3 Engineering PCB mezzanine uses clock signals for the cameras driven from the High Speed (HS Connector) connector. The

AISTARVISION PCB mezzanine offers a jumper selection for the clock (a 24MHz oscillator or the High Speed connector clock). This project uses a 24MHz oscillator as the clock signal source for the cameras.

We chose to leave the areas of the PCB Mezzanine that are close to the DragonBoard 410c antennas free of ground layers or components, so as not to impair the performance of the DragonBoard 410c RF antennas.

We also decided to leave the cameras aligned parallel to the larger edge of the PCB Mezzanine, in order to give as much distance between the cameras as possible. This greater distancing contributes to the better functioning of the stereoscopic computer vision algorithms.

### COST ANALYSIS

According to the costing sheet, we concluded that a significant saving in the total FOB cost of the customized PCB mezzanine is possible.

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## OBJECTIVES (CONTINUED)

The design concept of a typical camera mezzanine is relatively simple. This kind of PCB basically contains **DC / DC converters** and connectors (**Low Speed** signals, **High Speed signals**, and the for **camera modules**).

Due to the low density of components, we were able to design a two layer PCB, with copper filling on both sides (for ground plane). This will also help reduce the final cost of the product (compared to using PCB with 4 layers).

The unit cost (USD FOB) for manufacturing a two-layer PCB (reference: **PCBWAY.COM**) is 0.73 (quantity = 100) and 0.434 (quantity = 1000).

### ESTIMATED UNIT COST OF THE CUSTOM CAMERA MEZZANINE

	Qty=100	Qty=1000
Electronic Components	17.80	14.58
Camera Modules	50.00	50.00
PCB	0.73	0.43
TOTAL (USD, FOB)	68.53	65.01

In this analysis, we are excluding freight costs, PCB assembly and taxes (import taxes, government taxes). Prices are FOB.

For cost comparison purposes, we list some off-the-shelf mezzanines of the market:

### UNIT COST OF OFF-THE-SHELF CAMERA MEZZANINES

MODEL	MIPI ADAPTER 2.0	D3 CAMERA MEZZ OV5640
MANUFACTURER	AISTARVISION	D3 ENGINEERING
PRICE (USD,FOB)	75.00	151.40

## PROJECT ROAD MAP

Due to the empty areas available on the PCB, it is possible to include other interesting components that could interface the DragonBoard 410c through the LS and HS connectors. In this case, it would probably be necessary to use PCBs with more layers (probably 4 layers).

Examples of interesting components are :

- **Cellular Modem** (3G/4G/LTE Cat-M1)
- **CAN Peripheral**
- 9-axis **Inertial Sensor**

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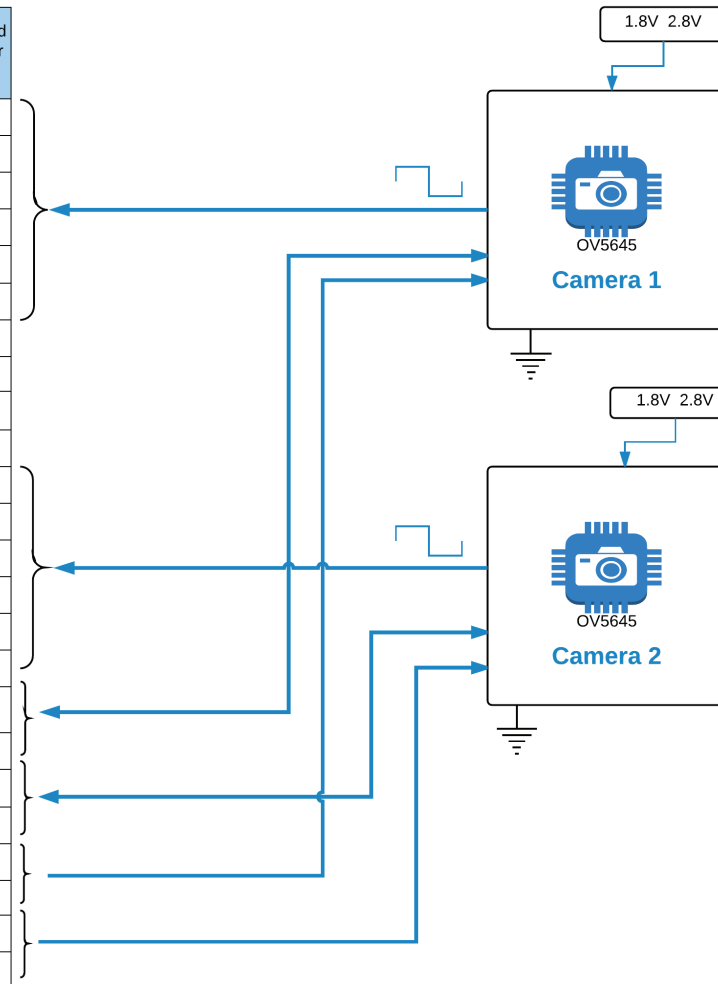
## MIPI CSI Cameras

The **Dragonboard 410c SBC** has two **MIPI-CSI** camera interfaces:  
 - 1x 4-lane (**MIPI\_CSI0**)  
 - 1x 2-lane (**MIPI\_CSI1**)

The **MIPI-CSI** signals are directly mapped to the High Speed connector of the **Dragonboard 410c**

The MIPI CSI cameras also require **I2C** interfacing.  
**MIPI\_CSI0** utilizes **I2C2** interface  
**MIPI\_CSI1** utilizes **I2C3** interface (\*)

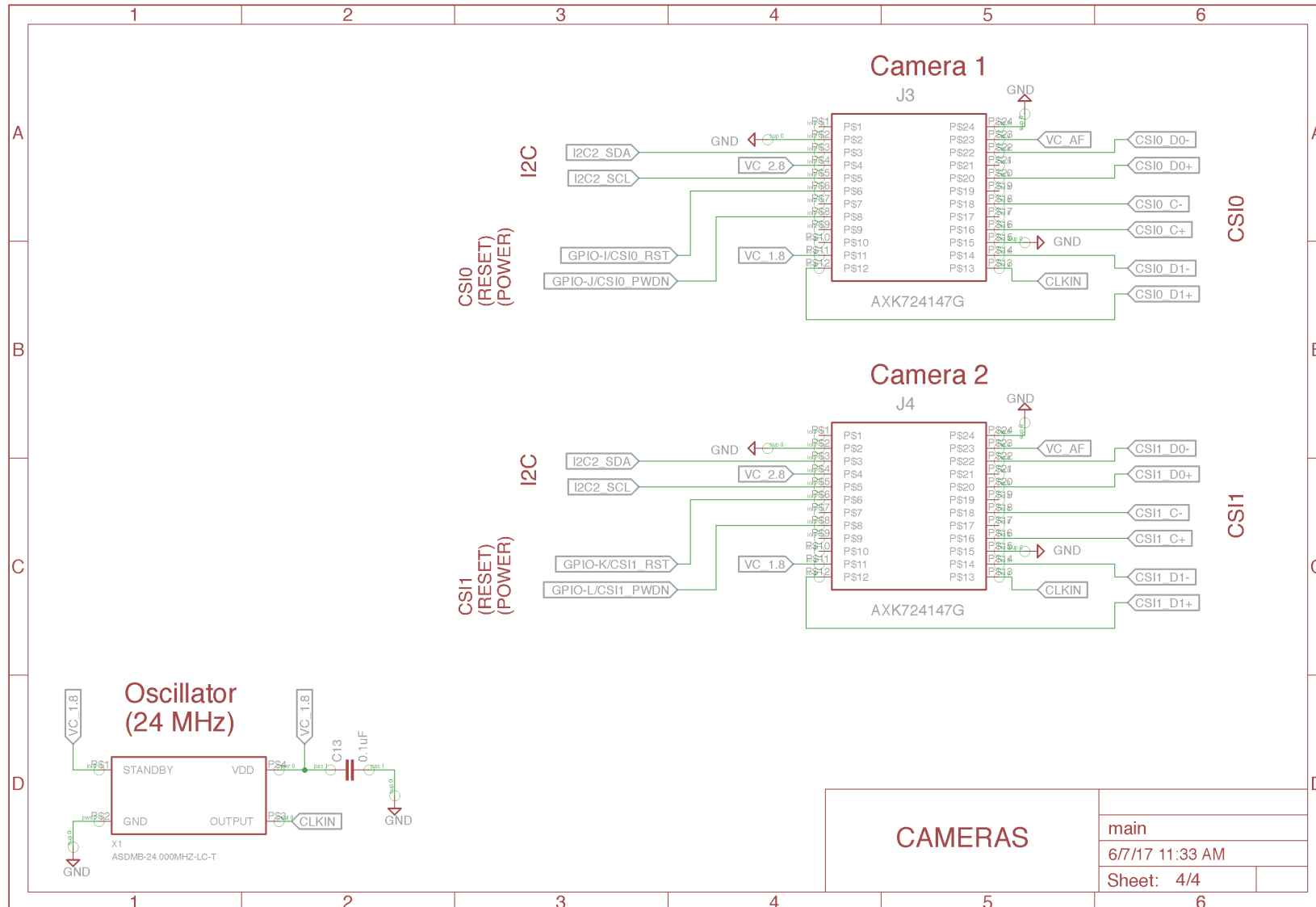
Module	SnapDragon 410E signal	96boards signal	High Speed Connector Pin	Low Speed Connector Pin
MIPI_CSI0 (primary)	MIPI_CSI0_CLK	CSI0_C+	2	
		CSI0_C-	4	
	MIPI_CSI0_D0	CSI0_D0+	8	
		CSI0_D0-	10	
	MIPI_CSI0_D1	CSI0_D1+	14	
		CSI0_D1-	16	
MIPI_CSI0_D2 (not used)	CSI0_D2+	20		
MIPI_CSI0_D3 (not used)	CSI0_D3+	26		
	CSI0_D3-	28		
MIPI_CSI1 (secondary)	MIPI_CSI1_CLK	CSI1_C+	54	
		CSI1_C-	56	
	MIPI_CSI1_D0	CSI1_D0+	42	
		CSI1_D0-	44	
MIPI_CSI1_D1	CSI1_D1+	48		
	CSI1_D1-	50		
I2C2	I2C2_SCL	I2C2_SCL/APQ GPIO30	32	
	I2C2_SDA	I2C2_SDA/APQ GPIO29	34	
I2C3 (*)	I2C3_SCL	I2C3_SCL/APQ GPIO15	36	
	I2C3_SDA	I2C3_SDA/APQ GPIO14	38	
PWDN0	CSI0_PWDN	APQ GPIO34		32
RESET0	CSI0_RST	APQ GPIO35		31
PWDN1	CSI1_PWDN	APQ GPIO33		34
RESET1	CSI1_RST	APQ GPIO28		33



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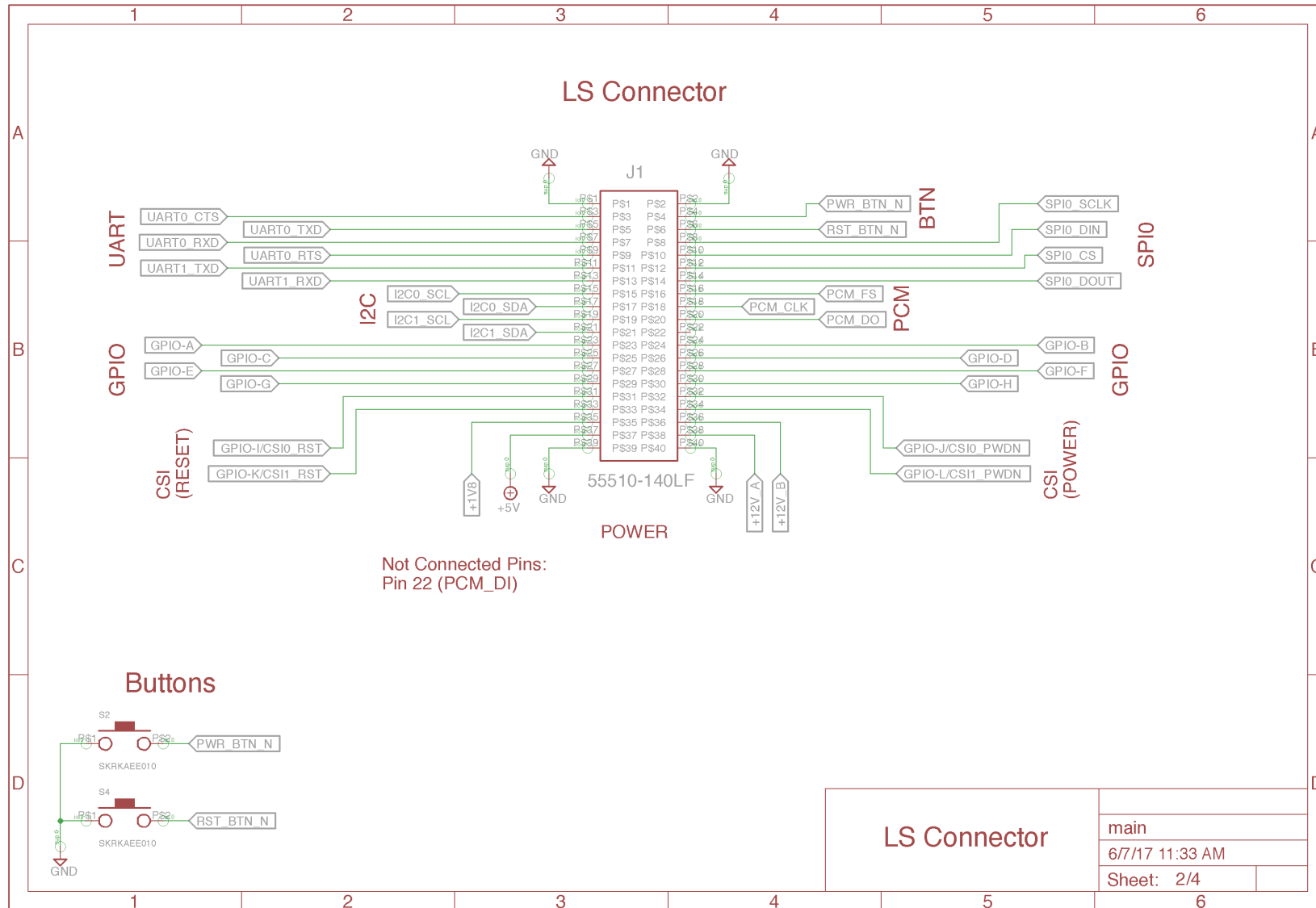
## MIPI-CSI CAMERAS SCHEMATICS



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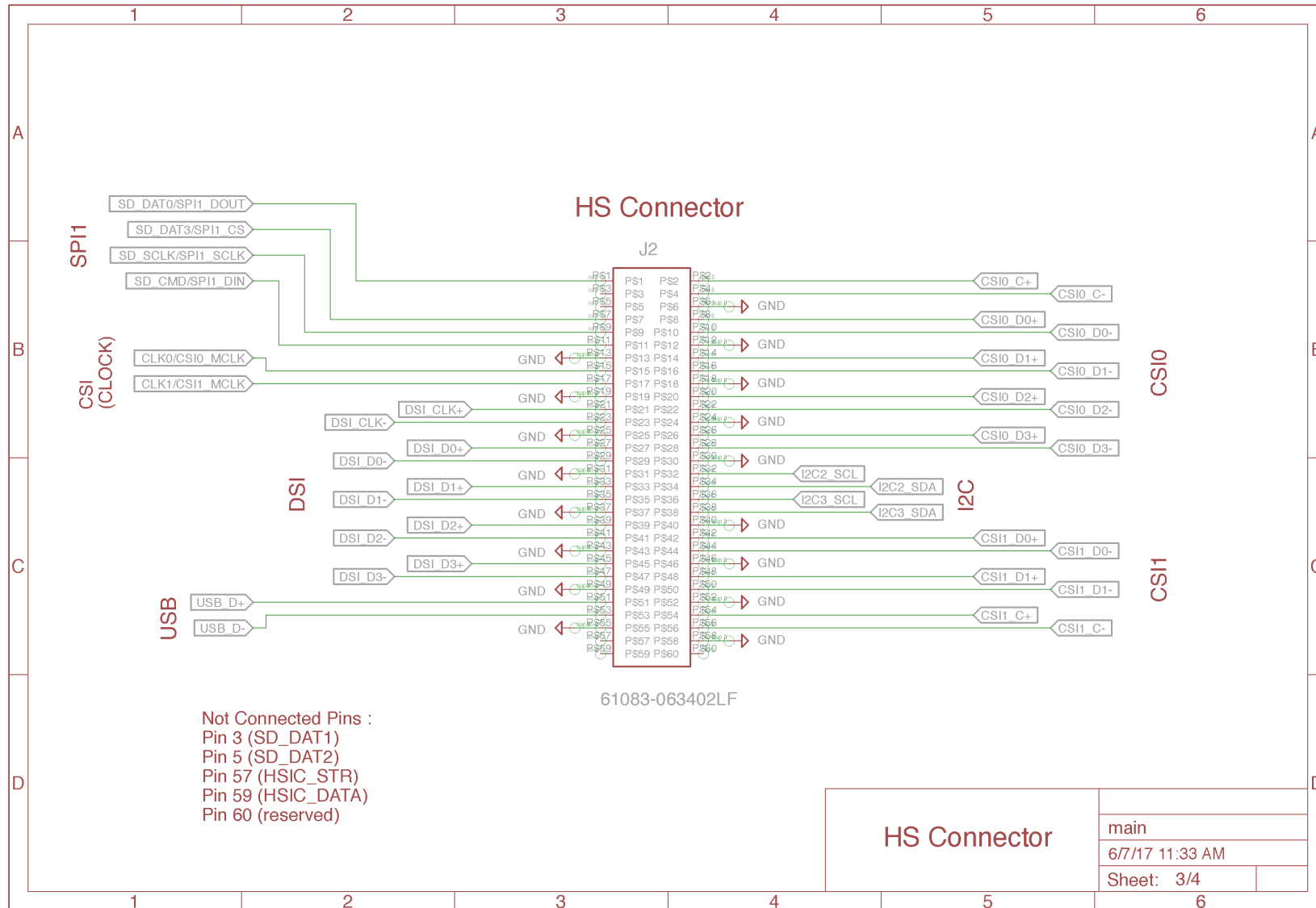
## LOW SPEED CONNECTOR SCHEMATICS



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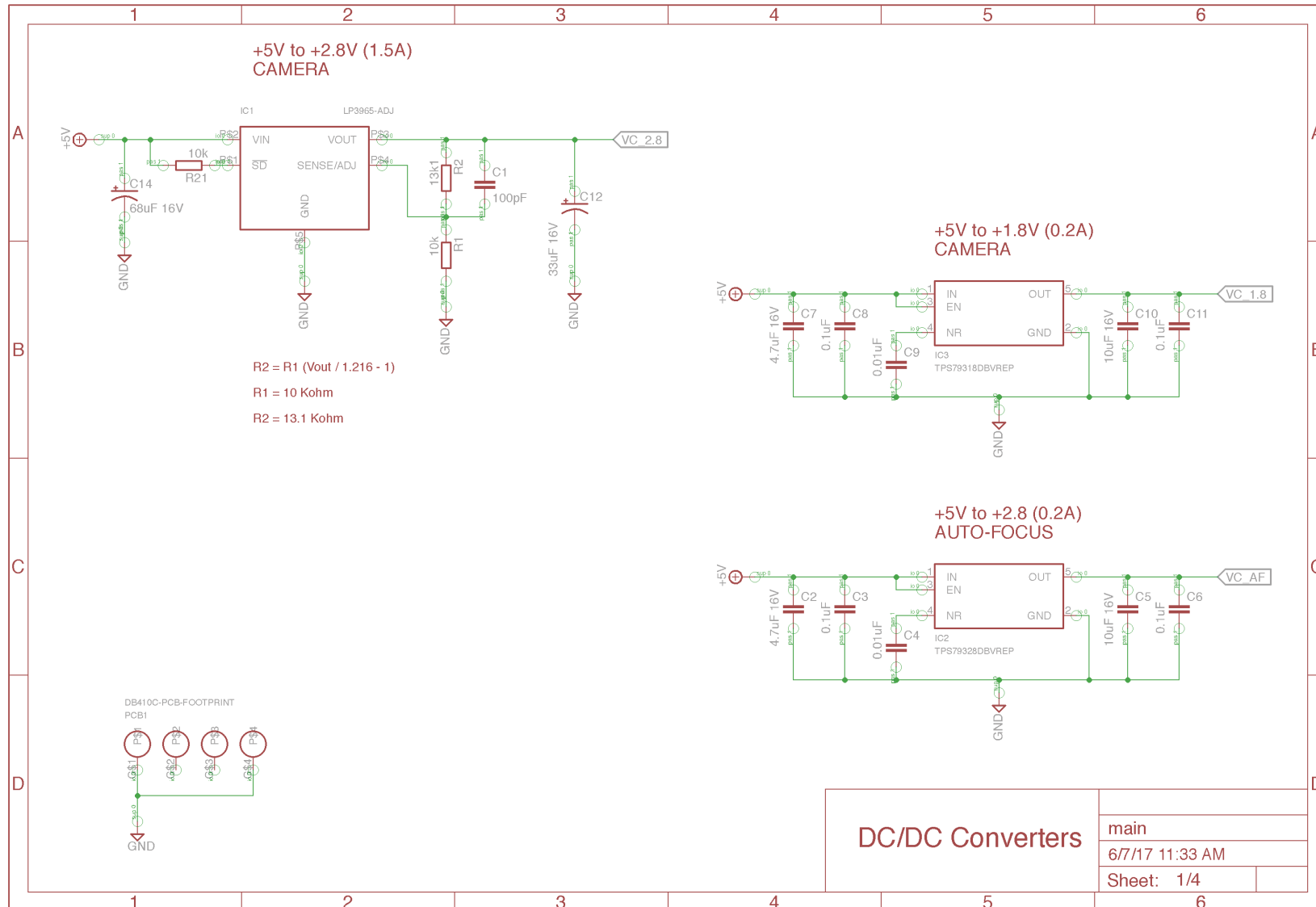
## HIGH SPEED CONNECTOR SCHEMATICS



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## DC/DC CONVERTERS SCHEMATICS

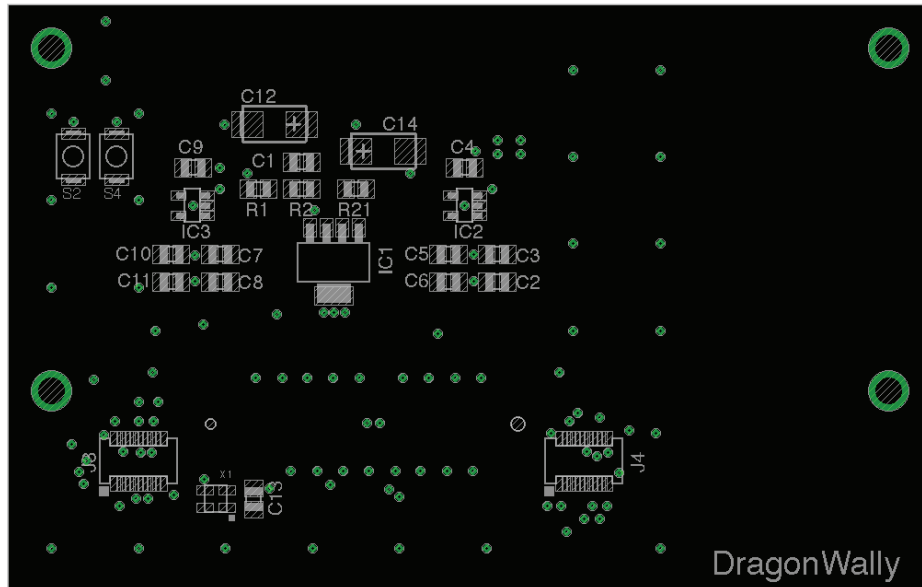


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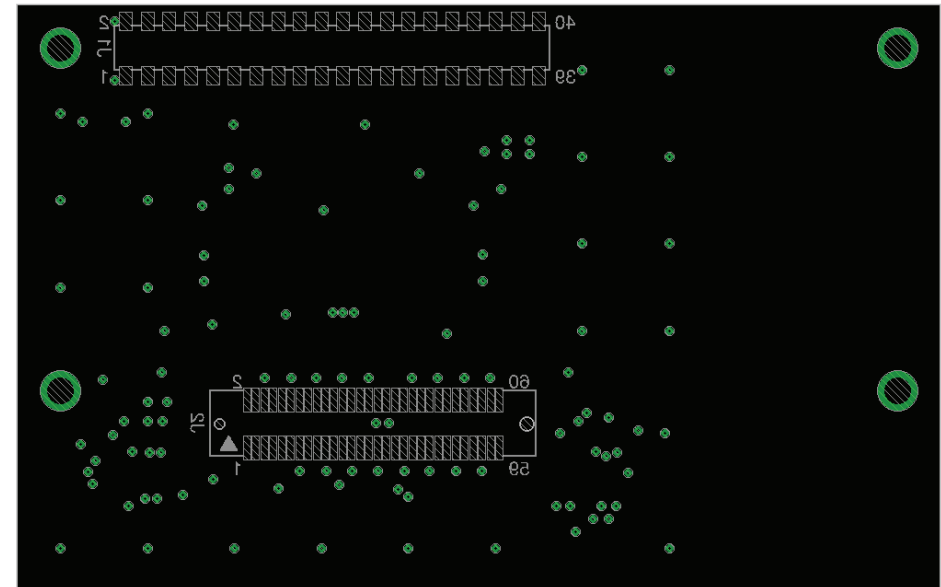
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## PCB LAYOUT (COMPONENTS PLACEMENT)

TOP SIDE



BOTTOM SIDE (MIRRORED)

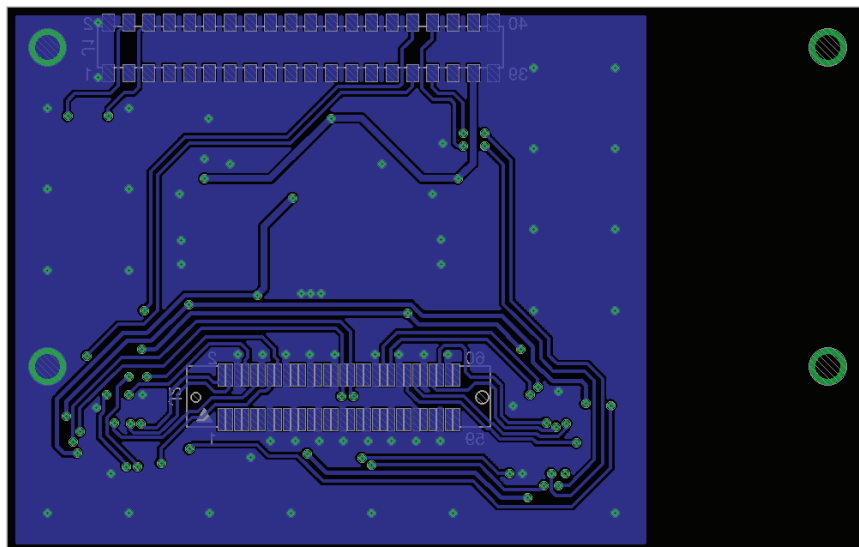
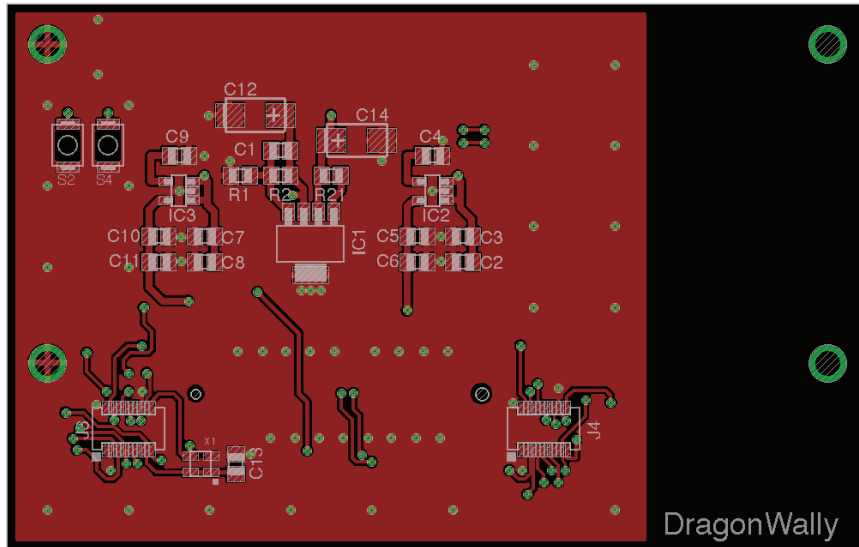




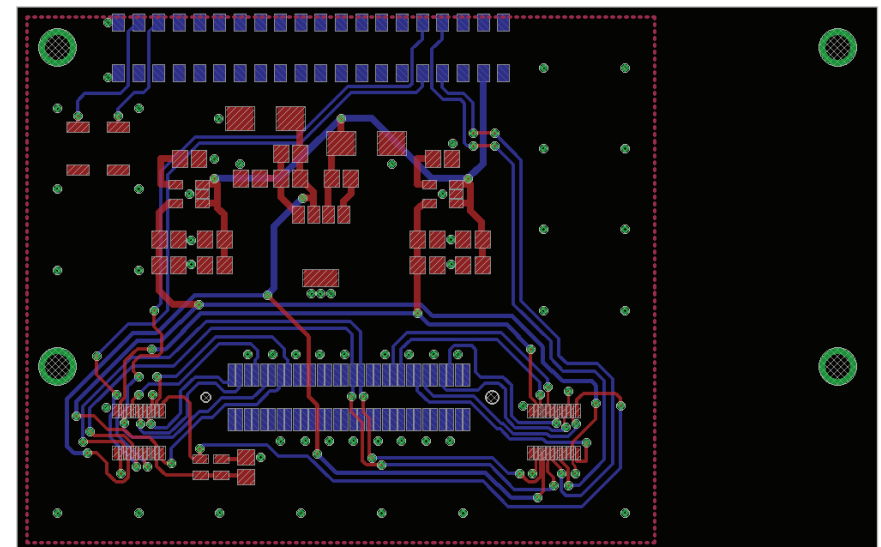
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## PCB LAYOUT (TOP AND BOTTOM COPPER LAYERS)



## OVERLAPPED LAYERS (TOP AND BOTTOM)



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## BOM (BILL OF MATERIALS)

### DRAGONWALLY MEZZANINE - BOM (BILL OF MATERIAL)

	PART	VALUE		PACKAGE	MANUFACTURER	PRICE (USD, FOB)			SUPPLIER
		VALUE	P/N			QTY=1	QTY=100	QTY=1000	
CAPACITORS	C1	100pF	08055A101JAT2A	C0805	AVX	0.1000	0.0630	0.0156	digkey
	C2	4.7uF 16V	0805YD475KAT2A	C0805	AVX	0.7200	0.3643	0.2429	digkey
	C3	0.1uF	08055C104KAT2A	C0805	AVX	0.1000	0.0141	0.0079	digkey
	C4	0.01uF	08055C103KAT2A	C0805	AVX	0.1000	0.0161	0.0090	digkey
	C5	10uF 16V	0805YD106KAT2A	C0805	AVX	0.2100	0.0721	0.0436	digkey
	C6	0.1uF	08055C104KAT2A	C0805	AVX	0.1000	0.0141	0.0079	digkey
	C7	4.7uF 16V	0805YD475KAT2A	C0805	AVX	0.7200	0.3643	0.2429	digkey
	C8	0.1uF	08055C104KAT2A	C0805	AVX	0.1000	0.0141	0.0079	digkey
	C9	0.01uF	08055C103KAT2A	C0805	AVX	0.1000	0.0161	0.0090	digkey
	C10	10uF 16V	0805YD106KAT2A	C0805	AVX	0.2100	0.0721	0.0436	digkey
	C11	0.1uF	08055C104KAT2A	C0805	AVX	0.1000	0.0141	0.0079	digkey
	C12	33uF 16V	TAJC336K016RNJ	CT6032	AVX	0.7200	0.3623	0.2625	digkey
	C13	0.1uF	08055C104KAT2A	C0805	AVX	0.1000	0.0141	0.0079	digkey
	C14	68uF 16V	TPSC686K016R0200	CT6032	AVX	1.3200	0.7797	0.4520	digkey
RESISTORS	R1	10k	ERJ-P06F1002V	R0805	panasonic	0.1900	0.0622	0.0260	digkey
	R2	13k1	ERJ-6ENF13R0V	R0805	panasonic	0.1000	0.0167	0.0075	digkey
	R3	10k	ERJ-P06F1002V	R0805	panasonic	0.1900	0.0622	0.0260	digkey
CONNECTORS	J1	55510-140LF	55510-140LF	55510-140LF	amphenol	4.2500	3.4008	2.4656	digkey
	J2	61083-063402LF	61083-063402LF	61083-063402LF	amphenol	4.8570	3.7370	3.2790	arrow
	J3	AXK724147G	AXK724147G	AXK724147G	panasonic	1.9779	1.8943	1.8107	arrow
	J4	AXK724147G	AXK724147G	AXK724147G	panasonic	1.9779	1.8943	1.8107	arrow
BUTTONS	S2	SKRKAEE010	SKRKAEE010	SKRKAEE010	alps	0.4668	0.4566	0.4543	arrow
	S4	SKRKAEE010	SKRKAEE010	SKRKAEE010	alps	0.4668	0.4566	0.4543	arrow
DC/DC	IC1	LP3965EMP-ADJ/NOPB	LP3965EMP-ADJ/NOPB	SOT223-5	Texas Instruments	2.3780	1.7800	1.4670	arrow
	IC2	TPS79328DBVREP	TPS79328DBVREP	SOT23-5	Texas Instruments	0.6082	0.3856	0.2511	arrow
	IC3	TPS79318DBVREP	TPS79318DBVREP	SOT23-5	Texas Instruments	1.0200	0.7107	0.4635	digkey
XTAL	X1	ASDMB-24.000MHZ-LC-T	ASDMB-24.000MHZ-LC-T	ASDMB	abracon	0.9411	0.7617	0.7057	arrow

TOTAL COST OF COMPONENTS		
QTY=1	QTY=100	QTY=1000
24.12	17.80	14.58

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## CAMERA MODULES

### DRAGONWALLY MEZZANINE – MIPI CSI CAMERA OPTIONS

	PART	VALUE		PACKAGE	MANUFACTURER	PRICE (USD, FOB)			SUPPLIER
		VALUE	P/N			QTY=1	QTY=100	QTY=1000	
CAMERAS	CAM1	AMC5014OV-ATV01	AMC5014OV-ATV01	camera module	AISTARVISION	25.00	25.00	25.00	AIStarVision
	CAM2	AMC5014OV-ATV01	AMC5014OV-ATV01	camera module	AISTARVISION	25.00	25.00	25.00	AIStarVision
	CAM1	LI-OV5640-MIPI-AF	LI-OV5640-MIPI-AF	camera module	Leopard Imaging	26.40	26.40	26.40	Arrow
	CAM2	LI-OV5640-MIPI-AF	LI-OV5640-MIPI-AF	camera module	Leopard Imaging	26.40	26.40	26.40	Arrow

### TOTAL COST OF TWO CAMERAS

MANUFACTURER	TOTAL COST
AISTARVISION	50.00
Leopard Imaging	52.80

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## MIPI ADAPTER MEZZANINE COMPARISON REVIEW

	AISTARVISION	D3 ENGINEERING
MODEL	MIPI Adapter 2.0 Mezzanine	D3 CAMERA MEZZ OV5640
I2C INTERFACE CSIO	I2C2	I2C2
I2C INTERFACE CS11	I2C2 (default) I2C0 , I2C1 or I2C3 (through headers)	I2C1 (default) I2C3 (resistor jumper)
CSIO CLOCK SOURCE	24MHz OSC (default) or HS Connector	HS connector (CSIO_MCLK)
CS11 CLOCK SOURCE	24MHz OSC (default) or HS Connector	HS connector (CS11_MCLK)
INTERNAL DC VOLTAGES	+1.8 VDC and +2.8 VDC	+1.5 VDC and +2.8 VDC
PRICE WITH 1 CAMERA (USD FOB)	50.00	125.00
PRICE WITH 2 CAMERAS (USD FOB)	75.00	151.40
CAMERA PART NUMBER	AMC5014OV-ATV01 (OV5645)	LI-OV5640-MIPI-AF (OV5640)
LATEST SUPPORTED DEBIAN VERSION	16.09	17.04
BOARD SUPPORT PACKAGE	boot image	Boot / rootfs images

AISTARVISION Support Page	<a href="https://github.com/Kevin-WSCU/96Boards-Camera">https://github.com/Kevin-WSCU/96Boards-Camera</a>
D3 ENGINEERING Support Page	<a href="https://github.com/D3Engineering/410c_camera_support/wiki">https://github.com/D3Engineering/410c_camera_support/wiki</a>