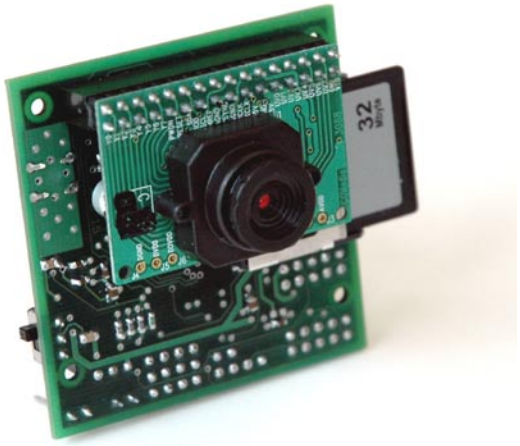

# CMUcam3 Datasheet

September 22, 2007

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# Contents



This is the CMUcam3 Datasheet v1.02 for the CMUcam3 Embedded Vision Sensor.
For more information go to http://www.cmucam.org or contact us at cmucam@cs.cmu.edu

Edited by Illah Nourbakhsh

# 1. INTRODUCTION

The CMUcam3 is an ARM7TDMI based fully programmable embedded computer vision sensor. The main processor is the Philips LPC2106 connected to an Omnivision CMOS camera sensor module. Custom C code can be developed for the CMUcam3 using a port of the GNU toolchain along with a set of open source libraries and example programs. Executables can be flashed onto the board using the serial port with no external downloading hardware required. Make sure to check www.cmucam.org for the most up to date documentaton and Quick-Start guides.

## Features

- CIF Resolution (352x288) RGB color sensor
- Open Source Development Environment for Windows and Linux
- MMC Flash Slot with FAT16 driver support
- Four-port Servo Controller
- Load Images into Memory at 26 Frames Per Second
- LUA light-weight language interpreter allows for rapid prototyping
- Software JPEG compression
- Basic Image Manipulation Library
  - Arbitrary Image Clipping
  - Image Downsampling
  - Mutable camera image properties
  - Threshold and Convolution Functions
  - RGB, YCrCb and HSV Color Space
- CMUcam2 Emulation
  - User defined color blobs
  - Frame differencing
  - Mean and variance data collection
  - Raw images dumps over serial
  - Histogram Generation
- B/W Analog video output (PAL or NTSC)*
- FIFO image buffer for multiple pass hi-res image processing
- Compatible Connector with Wireless Motes (Tmote Sky, FireFly, 802.15.4)

* Camera Properties Depend on Camera Module

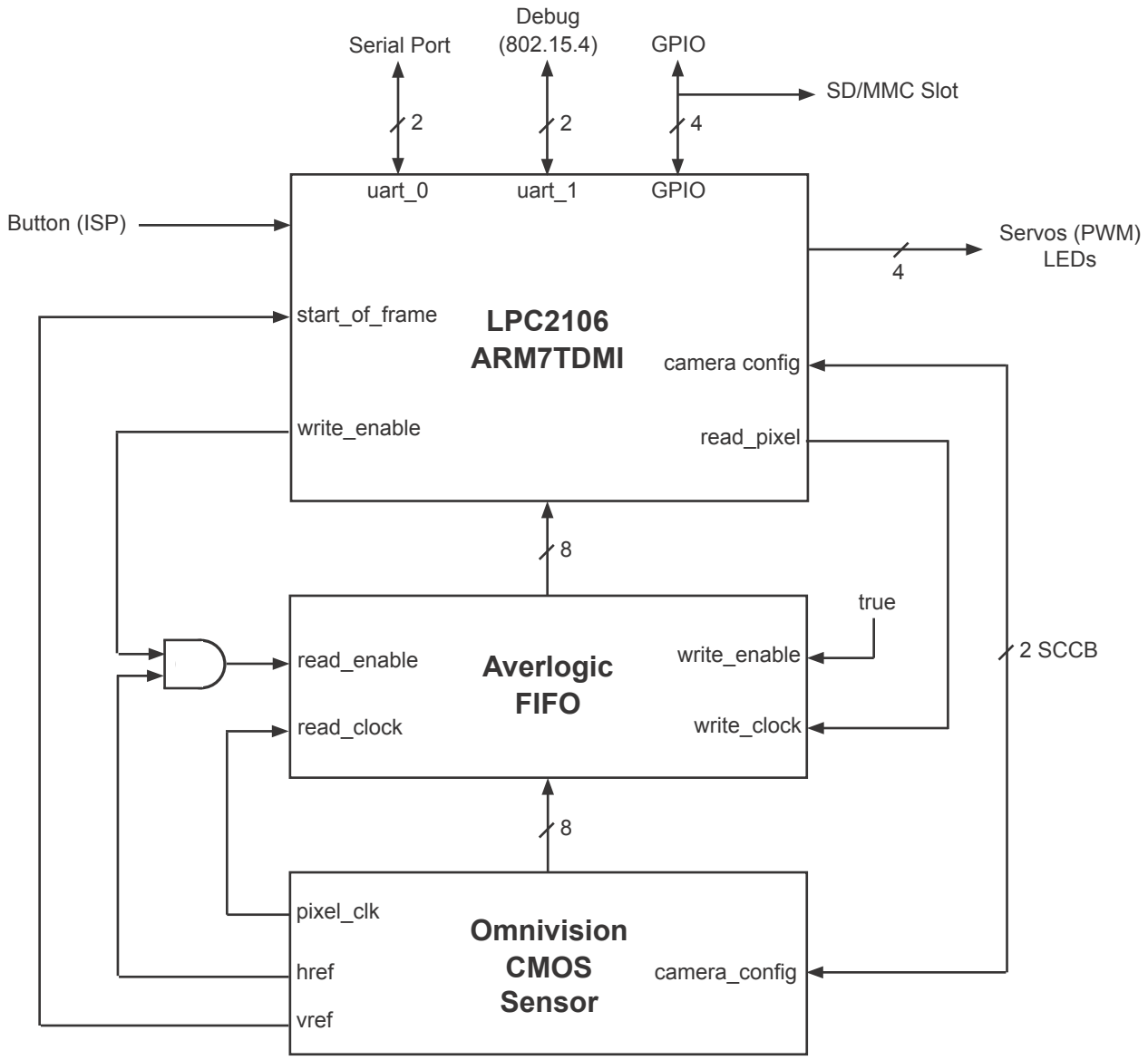
## Applications

The CMUcam3 is a hardware platform coupled with an open source development environment. It is targeted toward users that are already familiar with basic image processing and who are comfortable with microcontroller programming. For users who want basic image processing accessible through a simple serial interface and do not wish to implement their own algorithms, you can install a flash utility and download CMUcam2 emulation firmware. This allows the CMUcam3 to mimic the interface provided by the CMUcam2. Refer to the CMUcam2 user manual available on the CMUcam website for more information about CMUcam2 firmware functionality. The CMUcam3 can be used for a variety of applications including: While CMUcam2 functionality can be duplicated using CMUcam3, the major benefit of CMUcam3 stems from the ability of advanced users to directly program the system with their specific algorithms, even starting from the openly available firmware for CMUcam3 that emulates a majority of the CMUcam2 functionality.

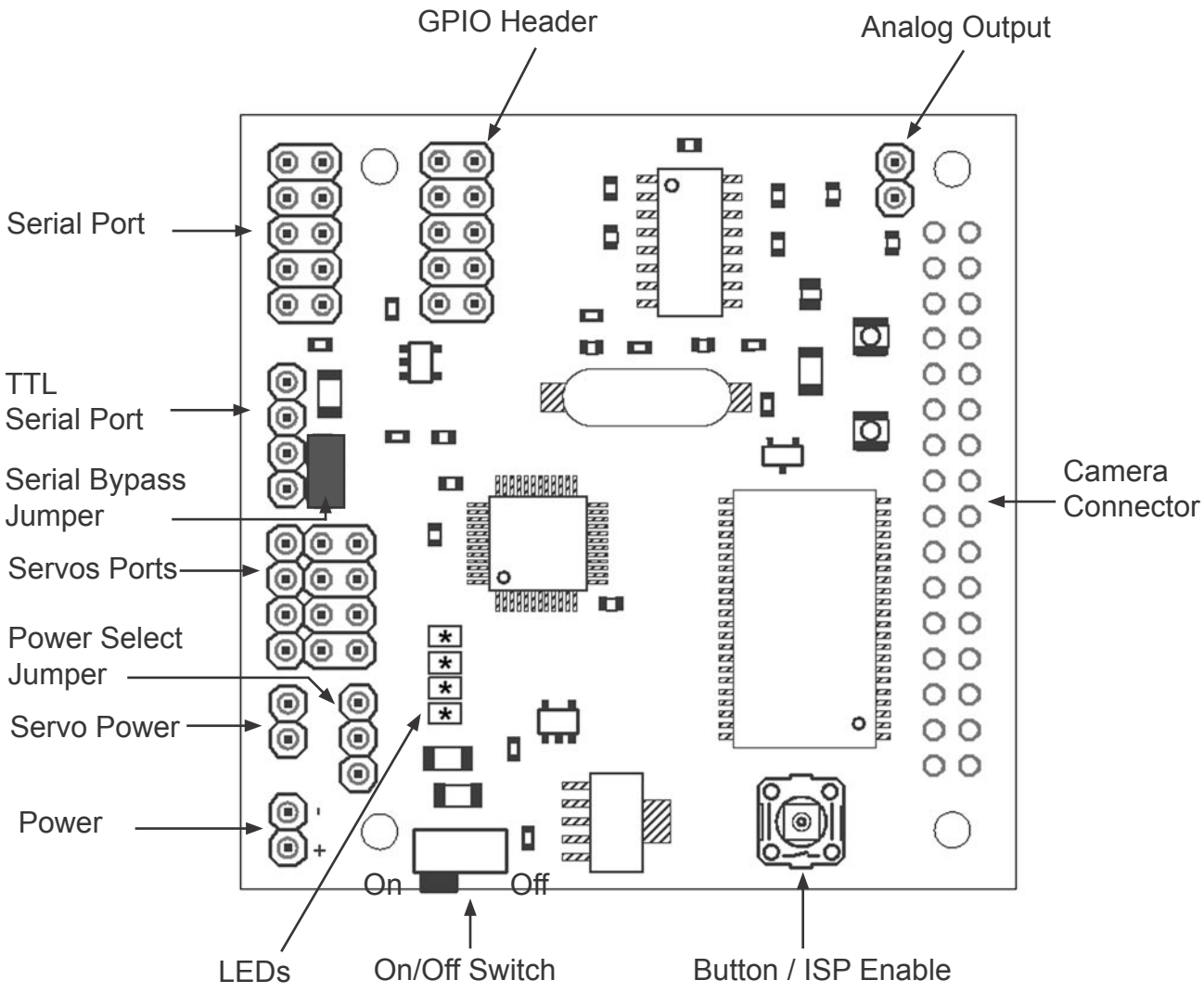
- Robotics
- Surveillance
- Sensor Networks
- Education
- Interactive Toys
- Object recognition and tracking
- Programmable Servo Control
- Serial MMC Flash Data Logging

# 2. BLOCK DIAGRAM

Below is a high level block diagram of the major components found on the CMUcam3.



# 3. HARDWARE CONNECTIONS

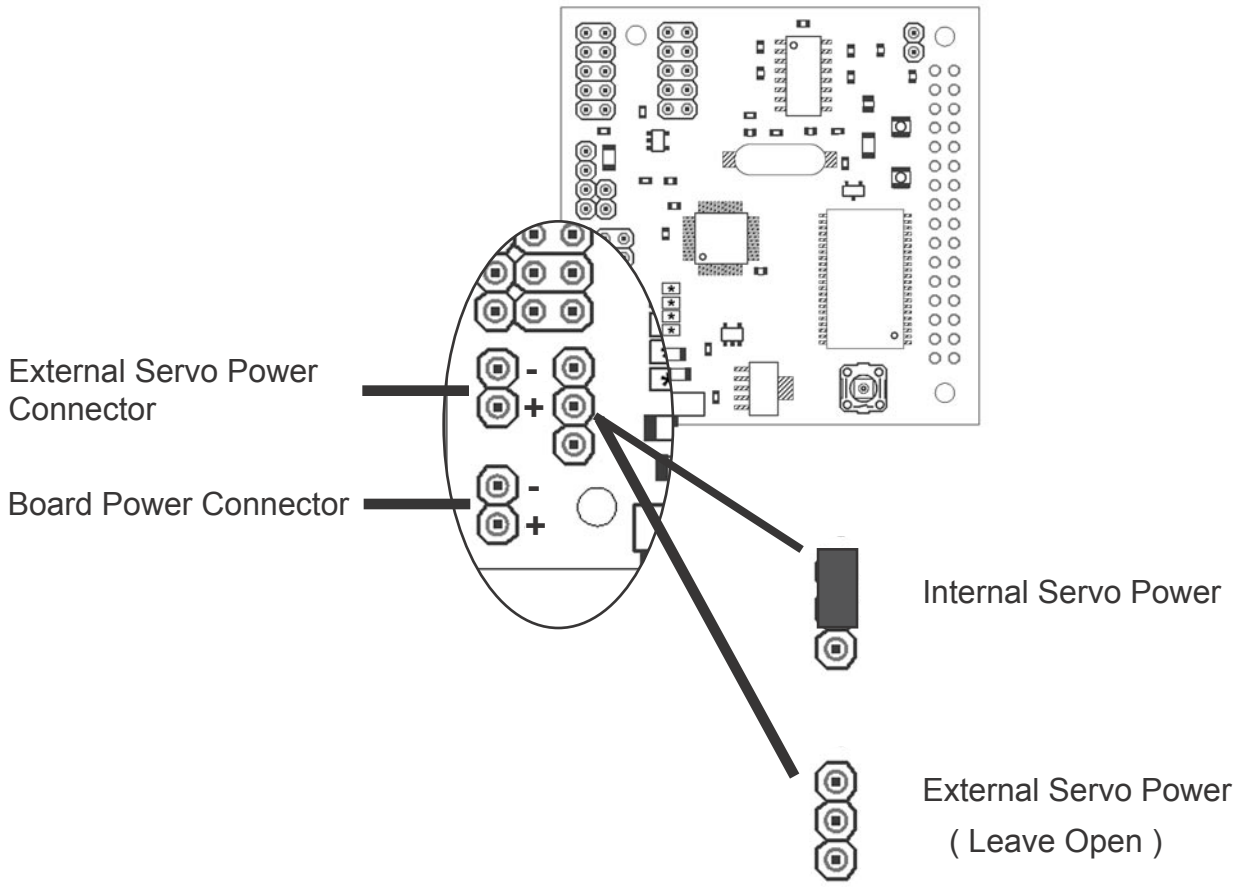


## Power

The input power to the board goes through a 5 volt regulator. It is ideal to supply the board with between 6 and 15 volts of DC power that is capable of supplying at least 150 milliamperes of current.

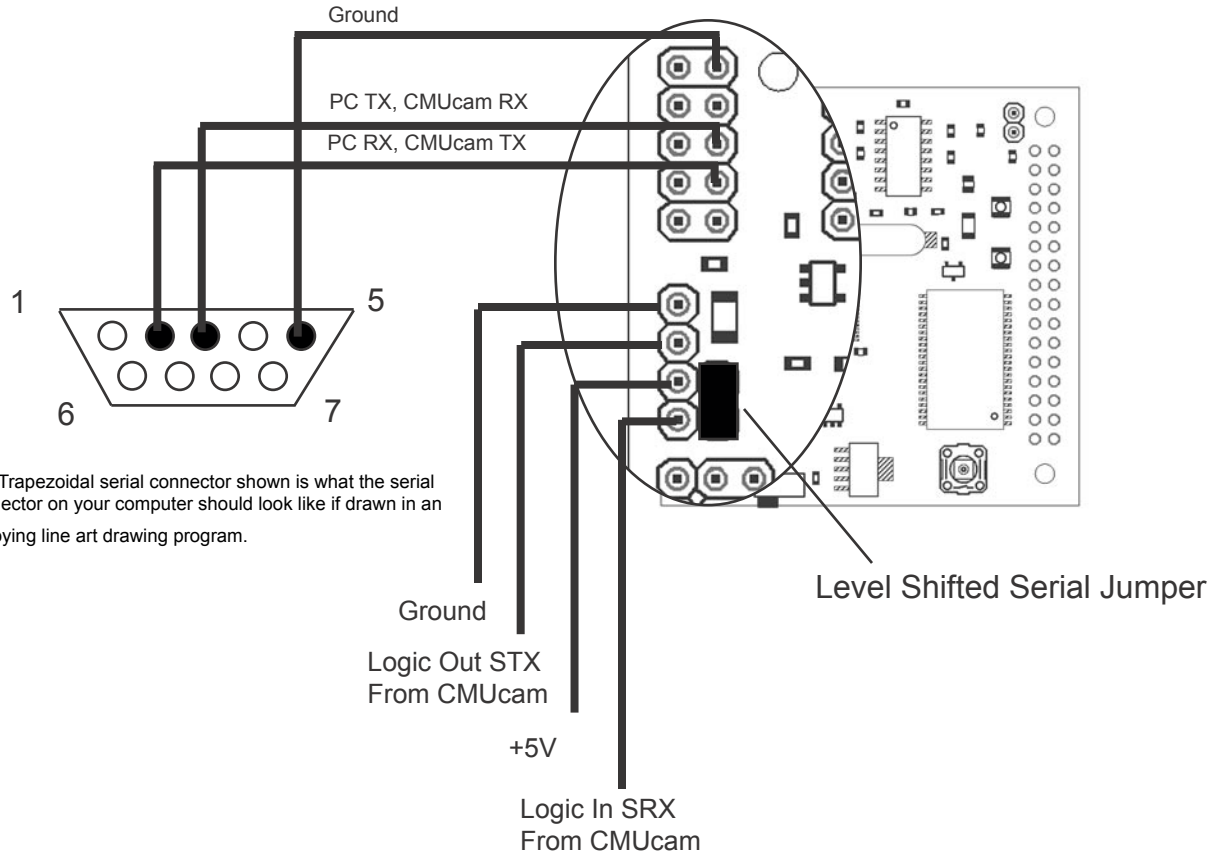
The servos can either be powered by internal power, or by the external servo power connector. To run them off of external power, remove the internal servo power jumper like shown below. Then connect a second power supply to the “External Servo Power Connector”. To run off of internal power, connect the “Internal Servo Power” jumper and disconnect any external servo power.

Warning: powering the servos from internal power means that if the servos require more current than is available to power both servos and the processor, then the processor may reset or fail to operate at all. Running three or more servos off of internal power will likely not succeed.



## Serial Port

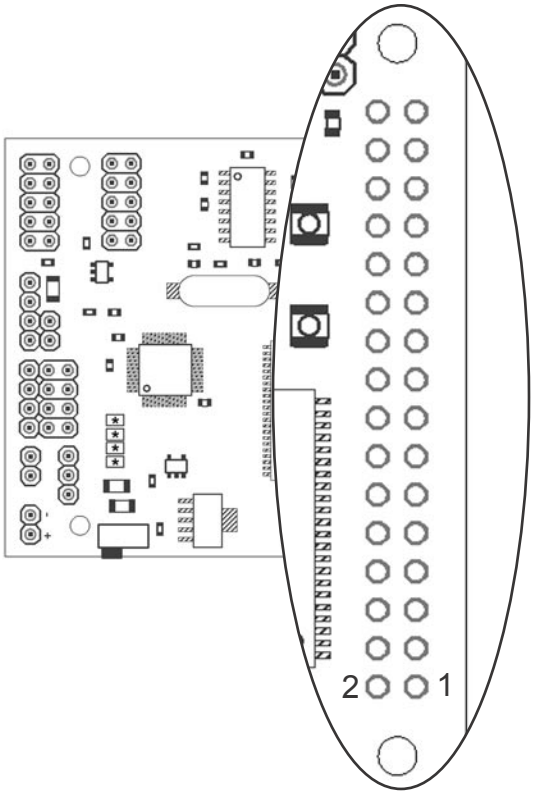
The CMUcam3 has a standard level shifted serial port to talk to a computer as well as a TTL serial port for talking to a microcontroller. The level shifted serial port only uses 3 of the 10 pins. It is in a 2x5 pin configuration that fits a standard 9 pin ribbon cable clip-on serial sockets and 10 pin female clip on serial headers that can both attach to a 10 wire ribbon cable. If this initially does not work, try flipping the direction that the ribbon cable connects to the CMUcam2 board. Make sure the serial jumper is in place when you use this mode. The TTL connector can be used to talk to a micrcontroller without the use of a level shifting chip. The TTL pins output between 0 and 3.3volts, but are 5 volt tolerant for input. Remove the Serial Jumper when you use this mode.



## Camera Bus

This bus interfaces with the CMOS camera chip. The CMOS camera board is mounted parallel to the processing part of the board and connects starting at pin 1. The female camera header should be soldered on the back of the main CMUcam3 board.

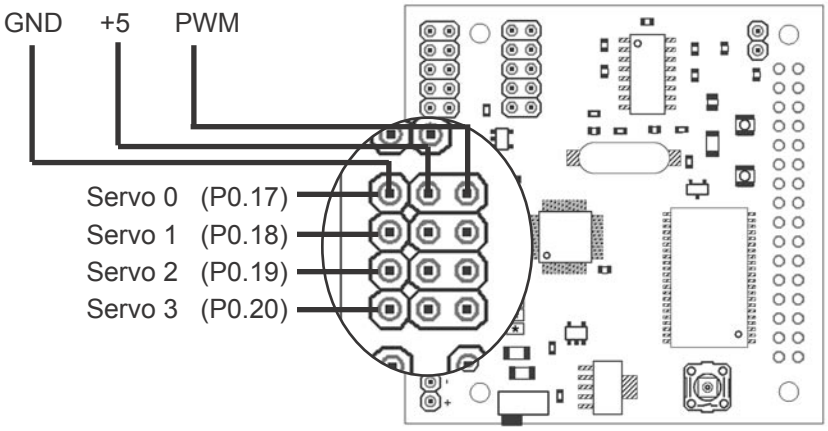
The CMUcam3 currently works with the OV6620 and OV7630 camera modules.




| | | |
|---|---|---|
| 1-8 | Y0-Y7 | Digital Output Y Bus |
| 9 | PWDN | Power Down Mode |
| 10 | RST | Reset |
| 11 | SDA | I2C Serial Data |
| 12 | FODD | Odd Field Flag |
| 13 | SCL | I2C Serial Clock |
| 14 | HREF | Horizontal Ref |
| 15 | AGND | Analog Ground |
| 16 | VSYNC | Vertical Sync |
| 17 | AGND | Analog Ground |
| 18 | PCLK | Pixel Clock |
| 19 | EXCLK | External Clock |
| 20 | VCC | +5 VDC |
| 21 | AGND | Analog Ground |
| 22 | VCC | +5 VDC |
| 23-30 | UV0-UV7 Digital Output UV BUS | |
| 31 | GND | Common Ground |
| 32 | VTO | Video Out (75Ohm) |

## Servo Port

The CMUcam3 has the ability to control 4 servos. This can be useful if you do not wish to use a separate servo controller. The servo port can also be used as a general purpose digital outputs.

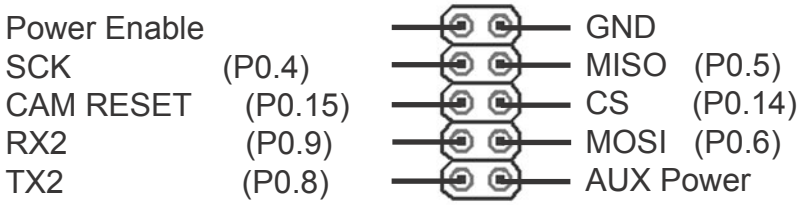


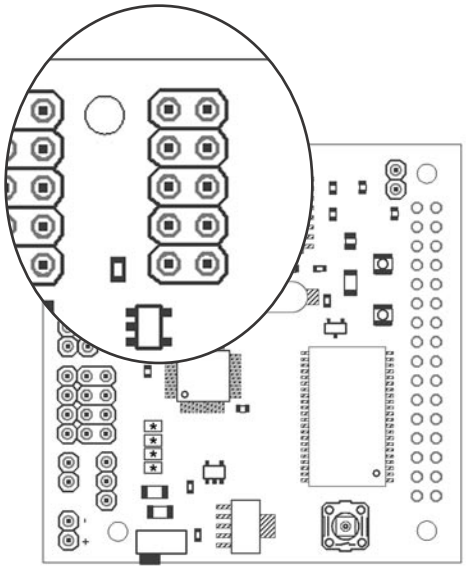
## Expansion Port GPIO

The general purpose I/O header allows access to the second UART, various power control pins and the SPI pins.

Power Enable - When pulled low, the main CMUcam3 regulator is disabled causing the board to draw less than 0.01uA. All devices are shutoff and lose all active state information. When the line is released or pulled high, the board will reboot. By default, the pin is internally pulled high.

AUX Power - This pin can be configured to either externally power the board, or power an expansion board. By default, the pin is connected to the 3.3volt internal supply. By removing resistor R11 and adding a jumper resistor in place of R6, the pin is connected to the main power before the 5 volt regulator.



CAM RESET - This pin can be used as external I/O if the camera state is not required. Normally this pin resets the camera module and should not be used.

TX2 - The transmit pin on UART2 is not level shifted and hence can not be directly connected to a PC or none TTL external device. This pin can also be used as GPIO.

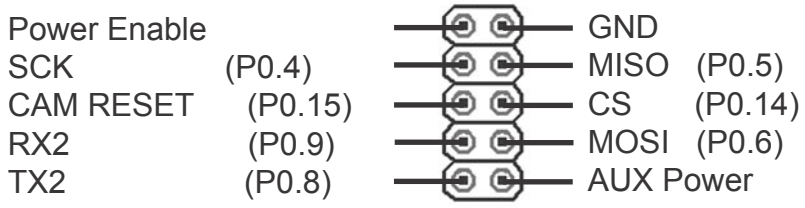
RX2 - The receive pin on UART2 is not level shifted and hence can not be directly connected to a PC or none TTL external device. This pin can also be used as GPIO.

CS - On reboot, if this pin is held low, the LPC2106 will enter bootstrap mode. Reboot can be externally induced by pulsing the power enable pin. Normally this pin will be controlled by the MMC driver. This pin can also be used as GPIO or as the SPI chip select when an MMC card is not inserted.

MOSI - Normally this pin is controlled by the MMC driver. This pin can also be used as GPIO or as an SPI output when an MMC card is not inserted.

MISO - Normally this pin is controlled by the MMC driver. This pin can also be used as GPIO or as an SPI input when an MMC card is not inserted.

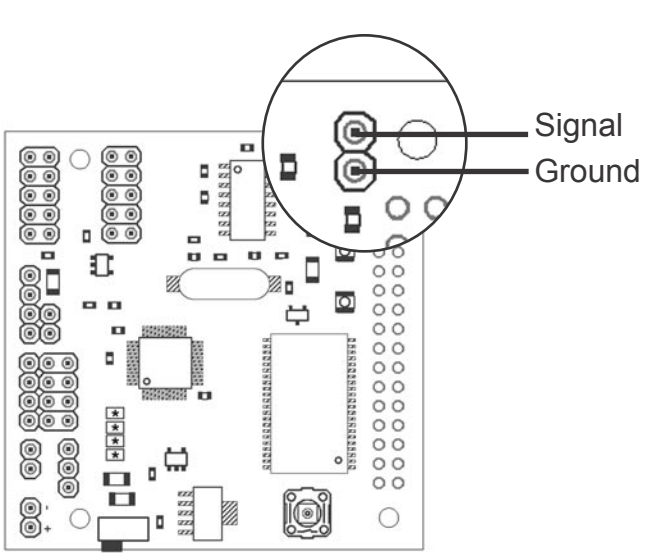
SCK - Normally this pin is controlled by the MMC driver. This pin can also be used as GPIO or as the SPI clock pin when an MMC card is not inserted.

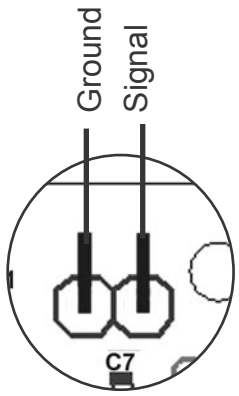


## Analog Output Port

Using the OV6620 camera module, you will be able to get a PAL video signal from the analog port of the CMUcam3. This would sync up with any PAL monitor, but will not work with a standard NTSC monitor. The OV7620 camera module will output a standard black and white NTSC video signal.

To use this output, it is necessary to keep the camera at its maximum frame rate (the default) and switch it into YCrCb mode in order to see the image on a monitor.



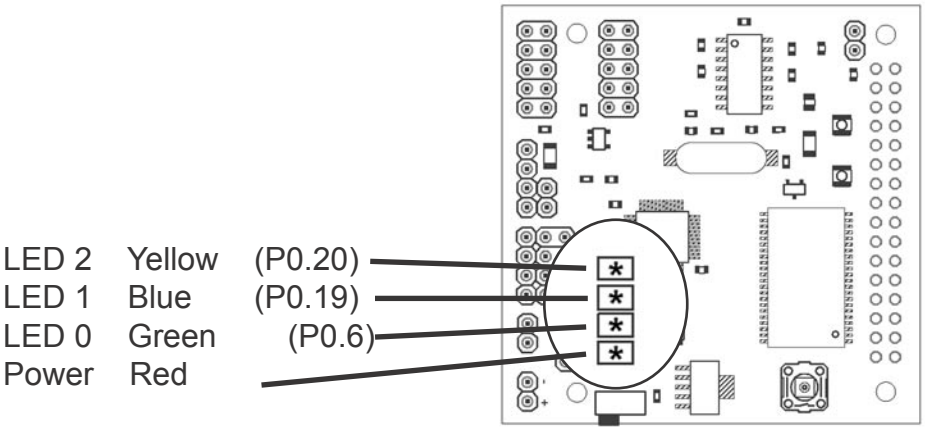

Board Revision B

## LEDs

LED 0 - This pin is shared with the MOSI pin and should be used only when CS is disabled while an MMC card is inserted.

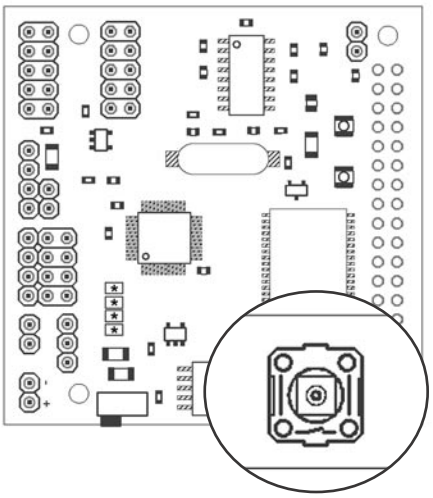
LED 1 - This pin is shared with the Servo 2 pin. When using Servo 2, the LED will flash.

LED 2 - This pin is shared with the Servo 3 pin. When using Servo 3, the LED will flash.



## ISP Button

When held down on power up, the ISP button will enable the built in LPC2106 bootloader. After the processor has started up, the button can be read as normal GPIO. It is internally pulled high, and set low when depressed. The button shares the CS pin (P0.14) with the MMC. When using the MMC, CS is active low and hence the button cannot adversely affect data transfers.



# 4. HARDWARE CHARACTERISTICS

| Power State | Active Current | Idle Current | Voltage |
|---|---|---|---|
| All Active | 130mA | 25mA | 5 V |
| External Regulator Disabled | n/a | 0.01uA | n/a |
| CPU (@60Mhz) | 30mA | 10uA | 1.8 V |
| CPU Peripherals | 30 | 10uA | 3.3 V |
| CMOS camera | 25mA | 10uA | 5 V |
| MAX232 | 8mA | n/a | 3.3 V |
| FIFO | 52mA | 14mA | 3.3 V |
| MMC card | 4mA | 4mA | 3.3 V |
| misc | 10mA | 10mA | 3.3 V |

Table 1: Power consumption information for various components.

| Component | | Description |
|---|---|---|
| CPU | | |
| | RAM | 64KB |
| | ROM | 128KB (8KB taken by bootloader) |
| | frequency | (14-60 Mhz) |
| FIFO | | |
| | Capacity | 1MB |
| | max rate | 50 FPS |
| CMOS camera | | |
| | max resolution | 352x288 |
| | color depth | 8bits per pixel |
| Misc | | |
| | max serial rate | 115,200 bits per second |
| | full resolution image load and pixel touch rate | 26 FPS |
| | servo frequency | 50 Hz |

Table 2: CMUcam3 Characteristics

# 5. INSTALLING FIRMWARE

The CMUcam3 can be loaded with various firmware images. These images may perform different specific tasks. For example, the “cmucam2.hex” file will allow your CMUcam3 to emulate the functionality of the CMUcam2. When you develop your own CMUcam3 applications or would like to experiment with new firmware images, it will be necessary to flash the microprocessor. Flashing the microprocessor can be done over a standard serial port using a downloading utility. These utilities are freely available for both Windows and Unix users. The next sections show step by step how to install a new firmware image onto your CMUcam3.

## Windows

1) The first step is to download and install a flash utility program. The “Philips LPC210x FLASH Utility” can be obtained from either the CMUcam (http://www.cmucam.org) or the Philips website.

http://www.semiconductors.philips.com/files/markets/microcontrollers/philips_flash_utility.zip

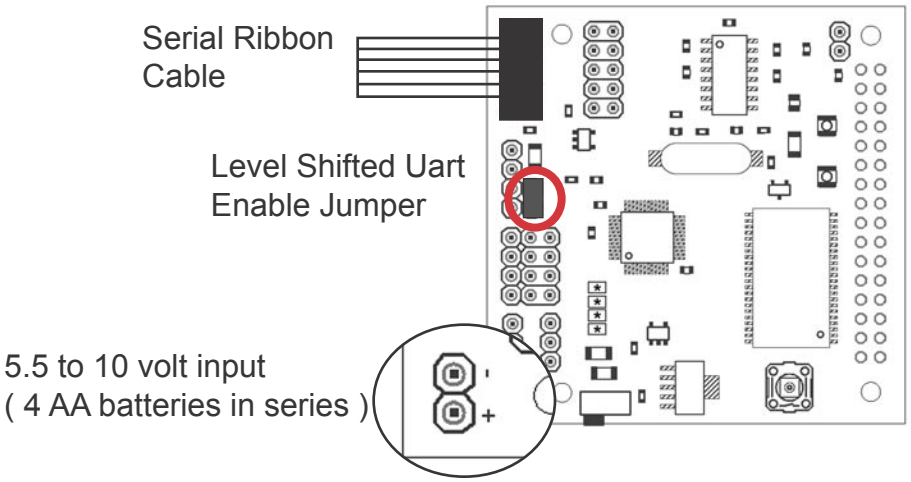
2) Double Click on the “philips_flash_utility.zip” icon.

3) Next Double Click on “setup.exe”

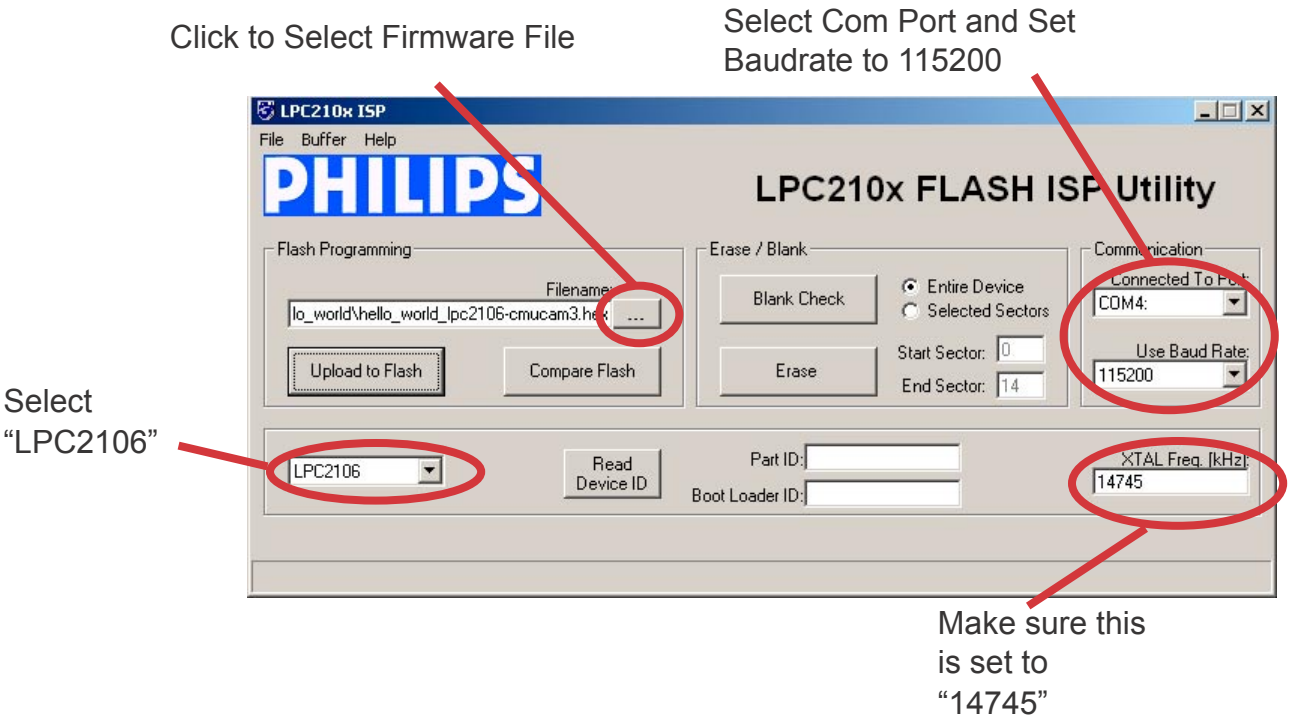
4) Click “Ok”

5) Click on the icon of the computer to continue the installation.

6) Once the Flash Utility is installed, connect the CMUcam3 to your serial port as shown below



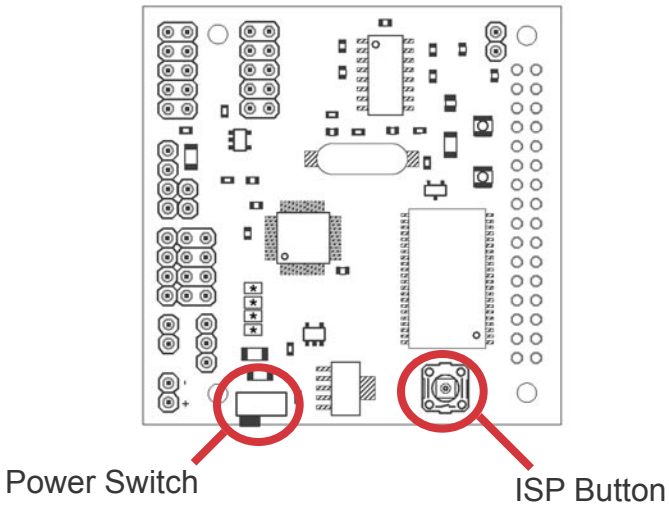

6) Go to the Start Menu, “All Programs”, “LPC210x ISP” and execute the “LPC210x ISP” application. You should eventually see a screen similiar to this:




7) Click on the “...” box next to “Filename” to select a hex file to download. As an example, select the “hello_world_lpc2106-cmucam3.hex” file located in the CMUcam3 hello_world project directory. Set the correct Comm Port and Device Selections.

8) Click on the “Upload to Flash” button. You should see a dialog box like below.


9) While holding down the “ISP” button on the camera, turn on the camera power. Make sure the button is held in for about a second. If the camera is already on, turn it off and on again while holding in the “ISP” button. If the button is depressed upon startup, the camera will enter its bootloader mode.




10) Press “OK” and wait for the image to download. If it fails check the connectors, reset the power and try again. The Flash Utility will say “File Upload Successfully Completed!” when the download is complete.

## Linux

In order to download to the board using linux, you must make sure you have proper access rights to the serial port. You can download a flash utility program from here:

http://guest.engelschall.com/~martin/lpc21xx/isp/
or
http://www.cmucam.org/wiki/Downloads

Install lpc21isp:

1) unzip lpc21isp_unix.zip
2) cd lpc21isp_unix
3) make
4) Add the directory with lpc21isp to your path

Follow the procedure outlines in the Windows section for putting the board into its bootloader mode by holding down the ISP button while reseting power to the board.

Once installed, here is a set of sample command line arguement for downloading:

```
>: cd CMUcam3/projects/hello_world
>: lpc21isp hello_world_lpc2106-cmucam3.hex /dev/ttyS0 115200 14745
```

Test the Firmware:

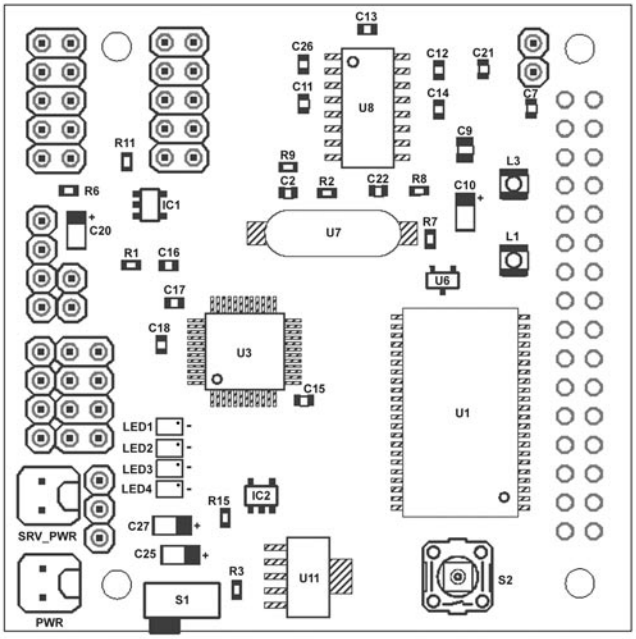
1) Open up a terminal program
2) Power Cycle Board
   A Green Power LED should turn on. If the code is running correctly, the red LED will turn off and the blue and yellow LEDs will dimly illuminate
3) Make sure the board prints a startup message
   - Open Minicom or some other terminal program
   - Configure Minicom to be 115200 baud, 8N1, no hardware flow control / or handshaking
   -Restart the board and wait 5 seconds
   - You should see the following:

```
CMUcam2 v1.00 c6
:
```

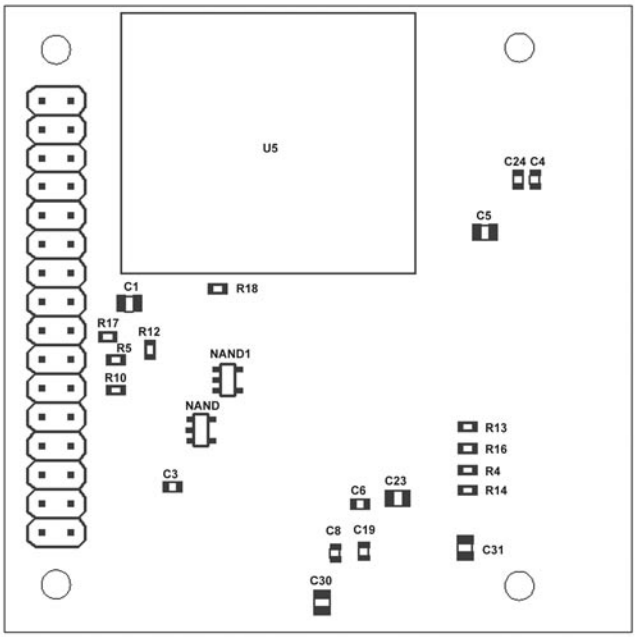
   - Try typing “gv” followed by enter to see if two-way serial communication is working correcly. The camera should respond.

# 6. ASSEMBLY INFORMATION

## Top Placement (Rev. A)

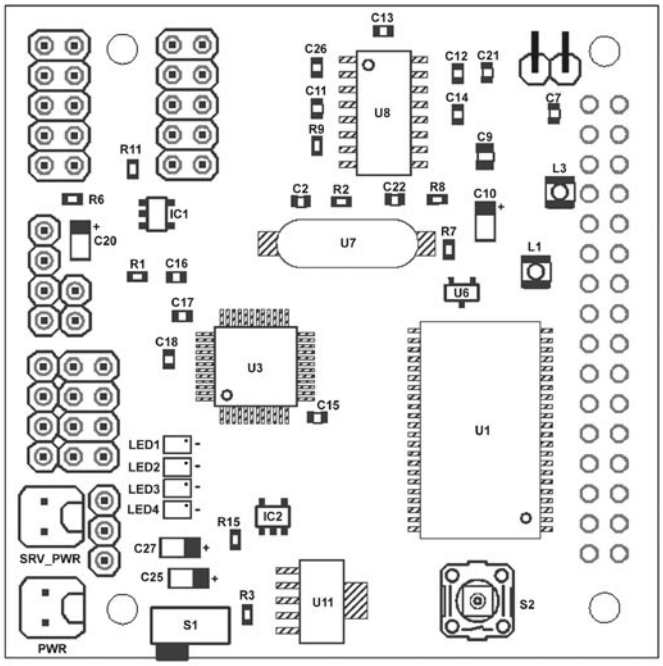



## Bottom Placement (Rev. A)

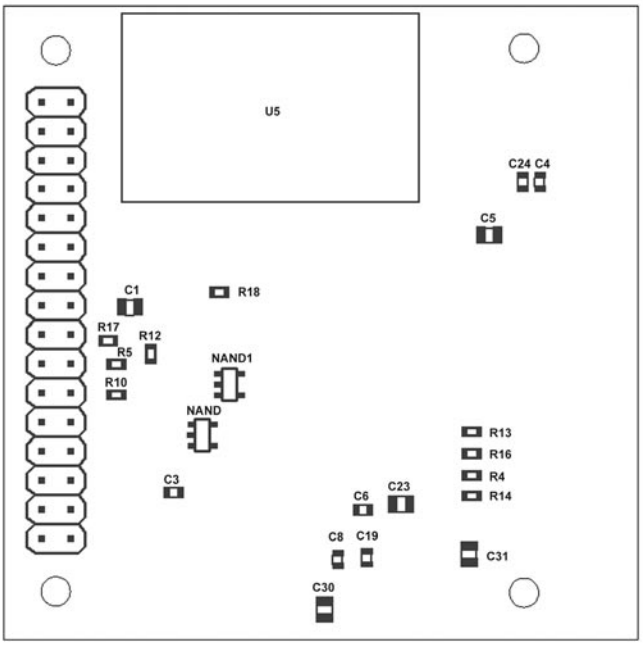



Note: Camera Bus Header on Bottom of Board.

## Top Placement (Rev. B)




## Bottom Placement (Rev. B)




Note: Camera Bus Header on Bottom of Board.

# Bill of Materials

| Part | Value | Device | Package | Description |
|---|---|---|---|---|
| C1 | 10uF | C-EUC0805 | C0805 | CAPACITOR |
| C2 | 33pF | C-EUC0603 | C0603 | CAPACITOR |
| C3 | .1uF | C-EUC0603 | C0603 | CAPACITOR |
| C4 | 1uF | C-EUC0603 | C0603 | CAPACITOR |
| C5 | 4.7uF | C-EUC0805 | C0805 | CAPACITOR |
| C6 | 1uF | C-EUC0603 | C0603 | CAPACITOR |
| C7 | .1uF | C-EUC0603 | C0603 | CAPACITOR |
| C8* | .01uF | C-EUC0603 | C0603 | CAPACITOR |
| C9 | 22uF | C-EUC0805 | C0805 | CAPACITOR |
| C10 | 33uF | C-EUC1206 | C1206 | CAPACITOR |
| C11 | 1uF | C-EUC0603 | C0603 | CAPACITOR |
| C12 | 1uF | C-EUC0603 | C0603 | CAPACITOR |
| C13 | 1uF | C-EUC0603 | C0603 | CAPACITOR |
| C14 | 1uF | C-EUC0603 | C0603 | CAPACITOR |
| C15 | .1uF | C-EUC0603 | C0603 | CAPACITOR |
| C16 | .1uF | C-EUC0603 | C0603 | CAPACITOR |
| C17 | .1uF | C-EUC0603 | C0603 | CAPACITOR |
| C18 | .1uF | C-EUC0603 | C0603 | CAPACITOR |
| C19 | .1uF | C-EUC0603 | C0603 | CAPACITOR |
| C20 | 33uF | C-EUC1206 | C1206 | CAPACITOR |
| C21 | .1uF | C-EUC0603 | C0603 | CAPACITOR |
| C22 | 33pF | C-EUC0603 | C0603 | CAPACITOR |
| C23 | 4.7uF | C-EUC0805 | C0805 | CAPACITOR |
| C24* | .01uF | C-EUC0603 | C0603 | CAPACITOR |
| C25 | 33uF | C-EUC1206 | C1206 | CAPACITOR |
| C26 | 1uF | C-EUC0603 | C0603 | CAPACITOR |
| C27 | 15uF | C-EUC1206 | C1206 | CAPACITOR |
| C30 | .01uF | C-EUC0805 | C0805 | CAPACITOR |
| C31 | .1uF | C-EUC0805 | C0805 | CAPACITOR |
| R1 | 47K | R-US_R0603 | R0603 | RESISTOR |
| R2 | 1M | R-US_R0603 | R0603 | RESISTOR |
| R3 | 4.7K | R-US_R0603 | R0603 | RESISTOR |
| R4 | 470 | R-US_R0603 | R0603 | RESISTOR |
| R5 | 4.7K | R-US_R0603 | R0603 | RESISTOR |
| R6 | 0 | R-US_R0603 | R0603 | RESISTOR |
| R7 | 100K | R-US_R0603 | R0603 | RESISTOR |
| R8 | 4.7K | R-US_R0603 | R0603 | RESISTOR |
| R9 | 4.7K | R-US_R0603 | R0603 | RESISTOR |
| R10 | 4.7K | R-US_R0603 | R0603 | RESISTOR |
| R11** | 0 (alt.) | R-US_R0603 | R0603 | RESISTOR |
| R12 | 10 | R-US_R0603 | R0603 | RESISTOR |
| R13 | 220 | R-US_R0603 | R0603 | RESISTOR |
| R14 | 1K | R-US_R0603 | R0603 | RESISTOR |
| R15 | 4.7K | R-US_R0603 | R0603 | RESISTOR |
| R16 | 470 | R-US_R0603 | R0603 | RESISTOR |
| R17 | 4.7K | R-US_R0603 | R0603 | RESISTOR |
| R18 | 4.7K | R-US_R0603 | R0603 | RESISTOR |

| Part | Value | Device | Package | Description |
|---|---|---|---|---|
| LED1 | yellow | 0604_LED | 0805 | LED |
| LED2 | blue | 0604_LED | 0805 | LED |
| LED3 | red | 0604_LED | 0805 | LED |
| LED4 | green | 0604_LED | 0805 | LED |
| L1 | 1uH | L-USL2825P | L2825P | INDUCTOR |
| L3 | 1uH | L-USL2825P | L2825P | INDUCTOR |
| NAND | SN74AHC | SN74AHC1 | SOT-23-5 | |
| NAND1 | SN74AHC | SN74AHC1 | SOT-23-5 | |
| IC1 | 3.3v | | SOT23-5 | VREG 3.3v |
| IC2 | 1.8v | | SOT23-5 | VREG 1.8v |
| U1 | AL440B | | TSOP44 | Averlogic AL440B FIFO |
| U3 | LPC2106 | LPC2106 | LQFP48 | |
| U5 | SD/MMC | SD/MMC | CCM05-5761 | |
| U6 | MCP809 | MCP809 | SOT-23 | |
| U7 | CSM-7 | CSM-7 | CSM-7 | |
| U8 | MAX232D | MAX232D | PSOP_14_SLIM | |
| U11 | 5V Reg | REG104 | SOT223-5 | |
| S1 | M251 | M251 | SLIDING SWITCH | |
| S2 | 10-XX | B3F-10XX | OMRON BUTTON | |
| CAMERA_BUS | | PINHD-2X16 | 2X16 | PIN HEADER |
| RS232_BYPASS | | PINHD-1X2 | 1X02 | PIN HEADER |
| JP1 | | PINHD-1X4 | 1X04 | PIN HEADER |
| JP2 | | PINHD-2X4 | 2X04 | PIN HEADER |
| JP3 | | PINHD-2X5 | 2X05 | PIN HEADER |
| JP4 | | PINHD-1X3 | 1X03 | PIN HEADER |
| PWR | | PINHD-1X2 | 1X02 | PIN HEADER |
| SRV_PWR | | PINHD-1X2 | 1X02 | PIN HEADER |
| TTL_1 | | PINHD-1X4 | 1X04 | PIN HEADER |
| UART_0 | | PINHD-2X5 | 2X05 | PIN HEADER |
| AN_OUT | | PINHD-1X2 | 1X02 | PIN HEADER |

**Revision B (Replace Following Components)**

| | | | |
|---|---|---|---|
| AN_OUT | SMD_HD-1X2 | 1X02 | SMD HEADER |
| U5 | SD/MMC | SD/MMC | CCM05-5777 |

* Do not install for TI regulators
** Do not install, alternate part for R6

## Part Numbers

| Qty | Digikey | Value | Device | Parts |
|---|---|---|---|---|
| 2 | WM4200-ND | | PINHD-1X2 | PWR, SRV_PWR |
| 2 | 399-1091-1-ND | .01uF | C-EUC0603 | C8, C24 |
| 1 | PCC103BNCT-ND | .01uF | C-EUC0805 | C30 |
| 8 | PCC1788CT-ND | .1uF | C-EUC0603 | C3, C7, C15, C16, C17, C18, C19, C21 |
| 1 | PCC1812CT-ND | .1uF | C-EUC0805 | C31 |
| 1 | P1.0KGCT-ND | 1K | R-US_R0603 | R14 |
| 2 | P470GCT-ND | 470 | R-US_R0603 | R4, R16 |
| 1 | P220GCT-ND | 220 | R-US_R0603 | R13 |
| 1 | P1.0MGCT-ND | 1M | R-US_R0603 | R2 |
| 7 | PCC1787CT-ND | 1uF | C-EUC0603 | C11, C12, C13, C14, C26, C4, C6 |
| 2 | 240-2389-1-ND | 40 Ohm | Ferrite Bead | L1, L3 |
| 8 | P4.7KGCT-ND | 4.7K | R-US_R0603 | R3, R5, R8, R9, R10, R15, R17, R18 |
| 2 | PCC2232CT-ND | 4.7uF | C-EUC0805 | C5, C23 |
| 1 | P10GCT-ND | 10 | R-US_R0603 | R12 |
| 1 | PCC2233CT-ND | 10uF | C-EUC0805 | C1 |
| 1 | 511-1464-1-ND | 15uF | C-EUC1206 | C27 |
| 2 | PCC1944CT-ND | 33pF | C-EUC0603 | C2, C22 |
| 1 | PCC2401CT-ND | 22uF | C-EUC0805 | C9 |
| 3 | 511-1451-1-ND | 33uF | C-EUC1206 | C10, C20, C25 |
| 1 | P47KGCT-ND | 47K | R-US_R0603 | R1 |
| 1 | P100KGCT-ND | 100K | R-US_R0603 | R7 |
| 1 | P0.0GCT-ND | JMPR | R-US_R0603 | R6 (default) or R11 |
| 1 | 404-1021-1-ND | GREEN | LED | L4 |
| 1 | 404-1017-1-ND | RED | LED | L3 |
| 1 | 404-1028-1-ND | BLUE | LED | L2 |
| 1 | 404-1019-1-ND | YELLOW | LED | L1 |
| 1 | XC1279CT-ND | 14.7456 | CSM-7 | U7 |
| 1 | 296-6938-5-ND | MAX232D | MAX232D | U8 |
| 1 | MCP809T-300I/TTCT-ND | MCP809/10 | MCP809/10 | U6 |
| 1 | 296-11021-1-ND | 3.3V | MIC5219BM5 | IC1 |
| 1 | 296-12520-1-ND | 1.8V | MIC5219BM5 | IC2 |
| 1 | REG104GA-5-ND | 5V Reg | REG102 | U11 |
| 1 | 401-1732-1-ND | SD/MMC | SD/MMC | U5 |
| 2 | 296-1087-1-ND | SN74AH | SN74 | SINGLE_NAND, SINGLE_NAND1 |
| 1 | A26525-40-ND | Dual Header | | JP2, JP3, UART_0, |
| 1 | A26465-ND | Dual Row Female | | *CAMERA_BUS |
| 1 | A26509-40-ND | Single Header | | AN_OUT, RS232_BYPASS, JP4, JP1, TTL_1 |
| 1 | EG1847-ND | Switch | Sliding Switch | S1 |
| 1 | SW400-ND | Push Button | Push Button | S2 |
| 1 | Philips | ARM7-TDMI | LPC2106 | U3 |
| 1 | Averlogic | FIFO | AL4V8M440 | U1 |

**Revision B (Replace Following Components)**

| | | | | |
|---|---|---|---|---|
| 1 | S1113E-36-ND | SMD RA Single Header | | AN_OUT |
| 1 | 401-1954-1-ND | SD/MMC | SD/MMC | U5 |

* CAMERA_BUS Header Soldered on Bottom Side of Board

# Placement Coordinates (Revision A)

## Top SMD Placement Coordinates

C2 31.23 40.47 180 33pF C0603
C7 52.69 47.88 270 .1uF C0603
C9 46.86 44.25 90 22uF C0805
C10 46.84 38.76 270 33uF C1206
C11 32.60 48.30 90 1uF C0603
C12 44.53 51.30 90 1uF C0603
C13 38.20 54.91 180 1uF C0603
C14 44.51 47.80 270 1uF C0603
C15 32.63 22.15 0 .1uF C0603
C16 20.68 34.05 0 .1uF C0603
C17 21.19 30.73 0 .1uF C0603
C18 20.02 27.07 90 .1uF C0603
C20 12.52 37.16 270 33uF C1206
C21 48.46 51.36 90 .1uF C0603
C22 39.20 40.64 180 33pF C0603
C25 21.69 8.46 180 33uF C1206
C26 32.57 51.80 90 1uF C0603
C27 20.98 11.13 180 15uF C1206
LED1 20.73 16.18 0 404-1021-1-ND 0805
LED2 20.70 14.35 0 404-1021-1-ND 0805
LED3 20.70 19.89 0 404-1021-1-ND 0805
LED4 20.70 17.98 0 404-1021-1-ND 0805
IC1 19.02 39.38 270 MIC5219BM5 SOT23-5
IC2 28.88 13.73 0 MIC5219BM5 SOT23-5
L1 51.16 34.49 90 1uH L2825P
L3 51.16 41.25 90 1uH L2825P
R1 17.36 34.05 180 47K R0603
R2 34.70 40.44 180 1M R0603
R3 26.56 5.51 270 4.7K R0603
R6 11.89 40.64 0 JMPR R0603
R7 43.78 36.34 270 100K R0603
R8 42.80 40.61 0 4.7K R0603
R9 31.23 42.74 180 4.7K R0603
R11 16.99 43.18 90 JMPR R0603
R15 25.68 11.76 270 4.7K R0603
U1 46.47 21.07 90 TSOP44
U3 27.40 26.42 0 LPC2106 LQFP48
U6 44.90 32.73 180 MCP809/10 SOT-23
U7 34.92 36.81 0 CSM-7 CSM-7
U8 38.23 48.01 270 MAX232D PSOP_14_SLIM
U11 32.99 6.60 270 REG102 SOT223-5

## Bottom SMD Placement Coordinates

C1 50.54 30.78 0 10uF C0805
C3 46.70 14.64 0 .1uF C0603
C4 14.72 41.70 270 1.0uF C0603
C5 19.14 37.07 0 4.7uF C0805
C6 30.17 13.13 180 1.0uF C0603
C8 32.35 8.78 90 .01uF C0603
C19 29.83 8.94 90 .1uF C0603
C23 26.83 13.63 180 4.7uF C0805
C24 16.22 41.70 270 .01uF C0603
C30 33.50 4.42 90 .01uF C0805
C31 20.90 9.22 90 .1uF C0805
R4 20.65 16.13 0 1K R0603
R5 51.70 25.81 0 4.7K R0603
R10 51.70 23.16 0 4.7K R0603
R12 48.70 26.73 270 10 R0603
R13 20.65 19.91 0 1K R0603
R14 20.65 14.30 0 1K R0603
R16 20.65 18.01 0 1K R0603
R17 52.43 27.84 180 4.7K R0603
R18 42.70 32.08 0 4.7K R0603
NAND 44.22 19.61 270 SN74AHC SOT-23-5
NAND1 41.85 24.01 270 SN74AHC SOT-23-5
U5 38.62 41.59 270 SD/MMC CCM05-5761

# Placement Coordinates (Revision B)

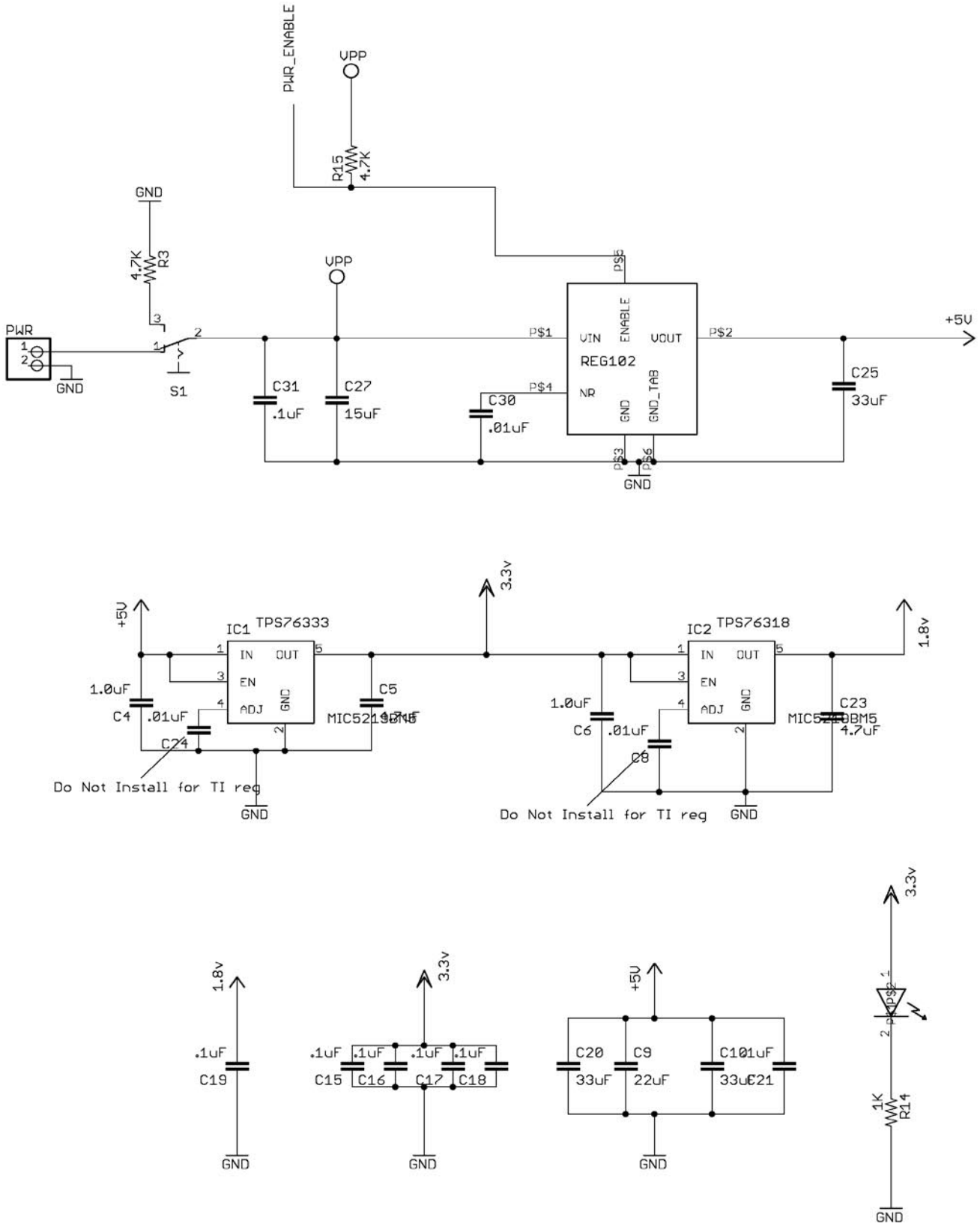
## Top SMD Placement Coordinates

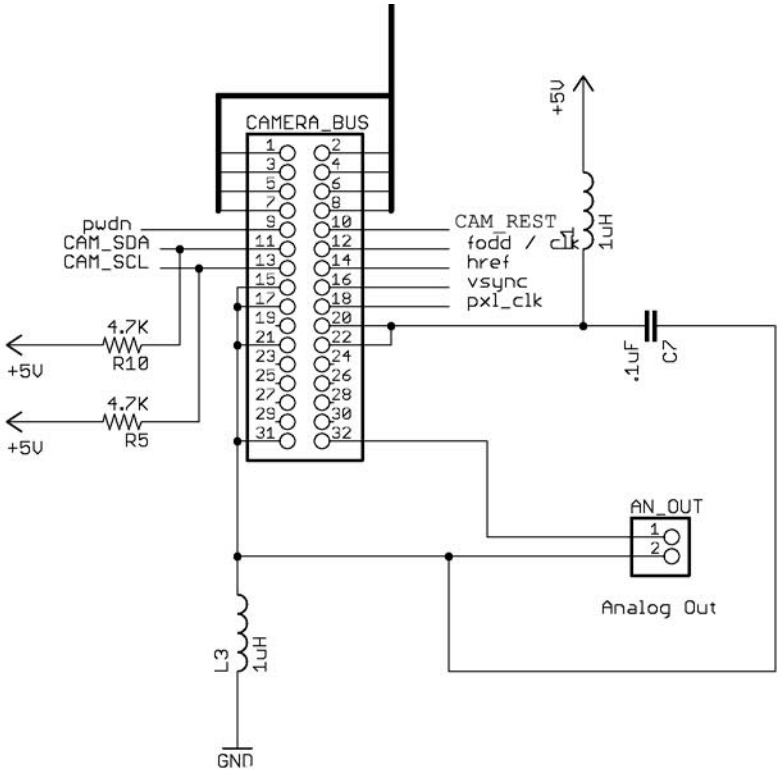
AN_OUT 51.94 52.07 90 2_SMT_RA_HEADER
C2 31.23 40.65 180 33pF C0603
C7 52.69 46.46 270 .1uF C0603
C9 46.51 44.25 90 22uF C0805
C10 46.48 38.94 270 33uF C1206
C11 32.60 48.30 90 1uF C0603
C12 44.53 51.30 90 1uF C0603
C13 38.20 54.91 180 1uF C0603
C14 44.51 47.80 270 1uF C0603
C15 32.63 22.15 0 .1uF C0603
C16 20.68 34.05 0 .1uF C0603
C17 21.19 30.73 0 .1uF C0603
C18 20.02 27.07 90 .1uF C0603
C20 12.52 37.16 270 33uF C1206
C21 47.93 51.36 90 .1uF C0603
C22 39.56 40.64 180 33pF C0603
C25 21.69 8.46 180 33uF C1206
C26 32.57 51.80 90 1uF C0603
C27 20.98 11.13 180 15uF C1206
LED1 20.73 16.18 0 404-1021-1-ND 0805
LED2 20.70 14.35 0 404-1021-1-ND 0805
LED3 20.70 19.89 0 404-1021-1-ND 0805
LED4 20.70 17.98 0 404-1021-1-ND 0805
IC1 19.02 39.38 270 MIC5219BM5 SOT23-5
IC2 28.88 13.73 0 MIC5219BM5 SOT23-5
L1 51.16 34.49 90 1uH L2825P
L3 52.58 41.25 90 1uH L2825P
R1 17.36 34.05 180 47K R0603
R2 34.70 40.62 180 1M R0603
R3 26.56 5.51 270 4.7K R0603
R6 11.89 40.64 0 JMPR R0603
R7 43.78 36.34 270 100K R0603
R8 42.80 40.61 0 4.7K R0603
R9 32.61 44.87 90 4.7K R0603
R11 16.99 43.18 90 JMPR R0603
R15 25.68 11.76 270 4.7K R0603
U1 46.47 21.07 90 TSOP44
U3 27.40 26.42 0 LPC2106 LQFP48
U6 44.90 32.73 180 MCP809/10 SOT-23
U7 34.92 37.34 0 CSM-7 CSM-7
U8 38.23 48.01 270 MAX232D PSOP_14_SLIM
U11 32.99 6.60 270 REG102 SOT223-5

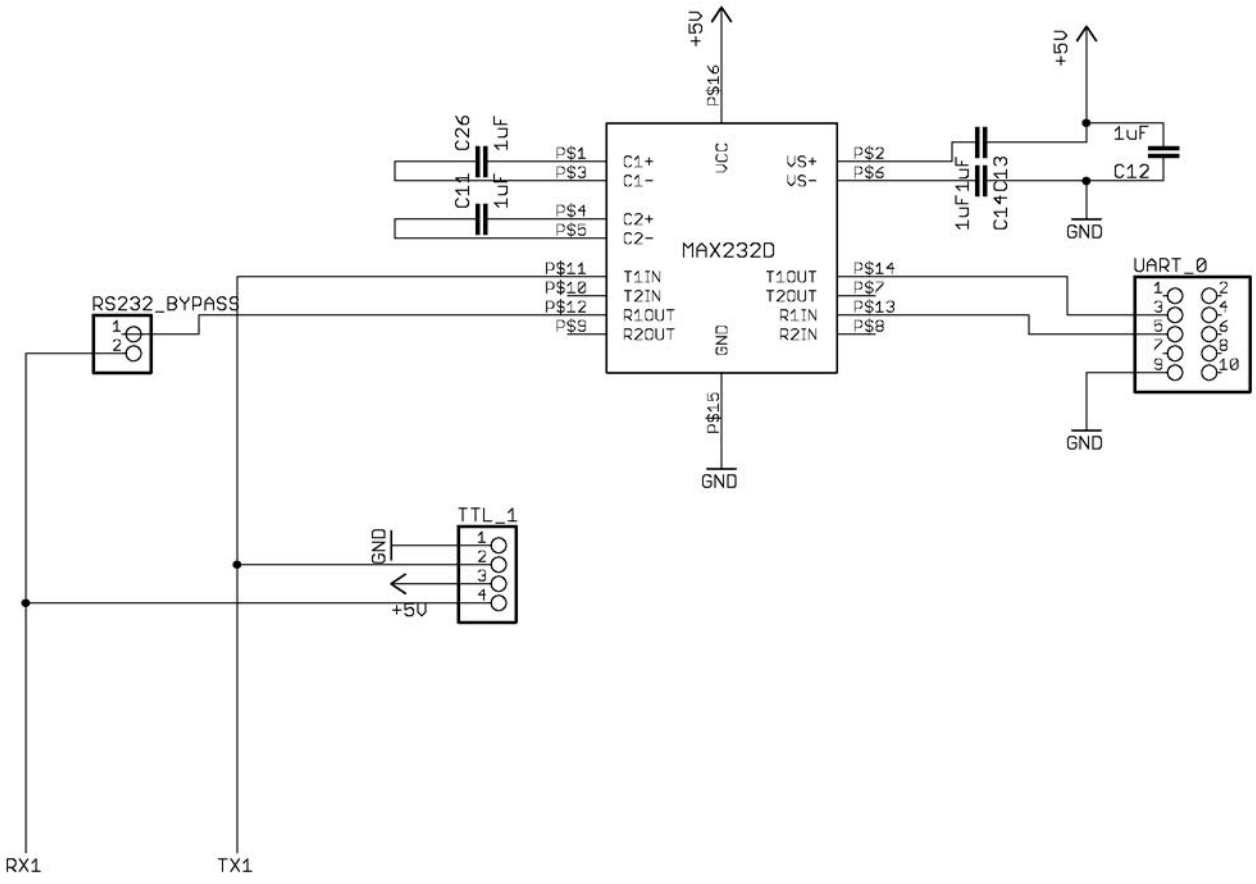
## Bottom SMD Placement Coordinates

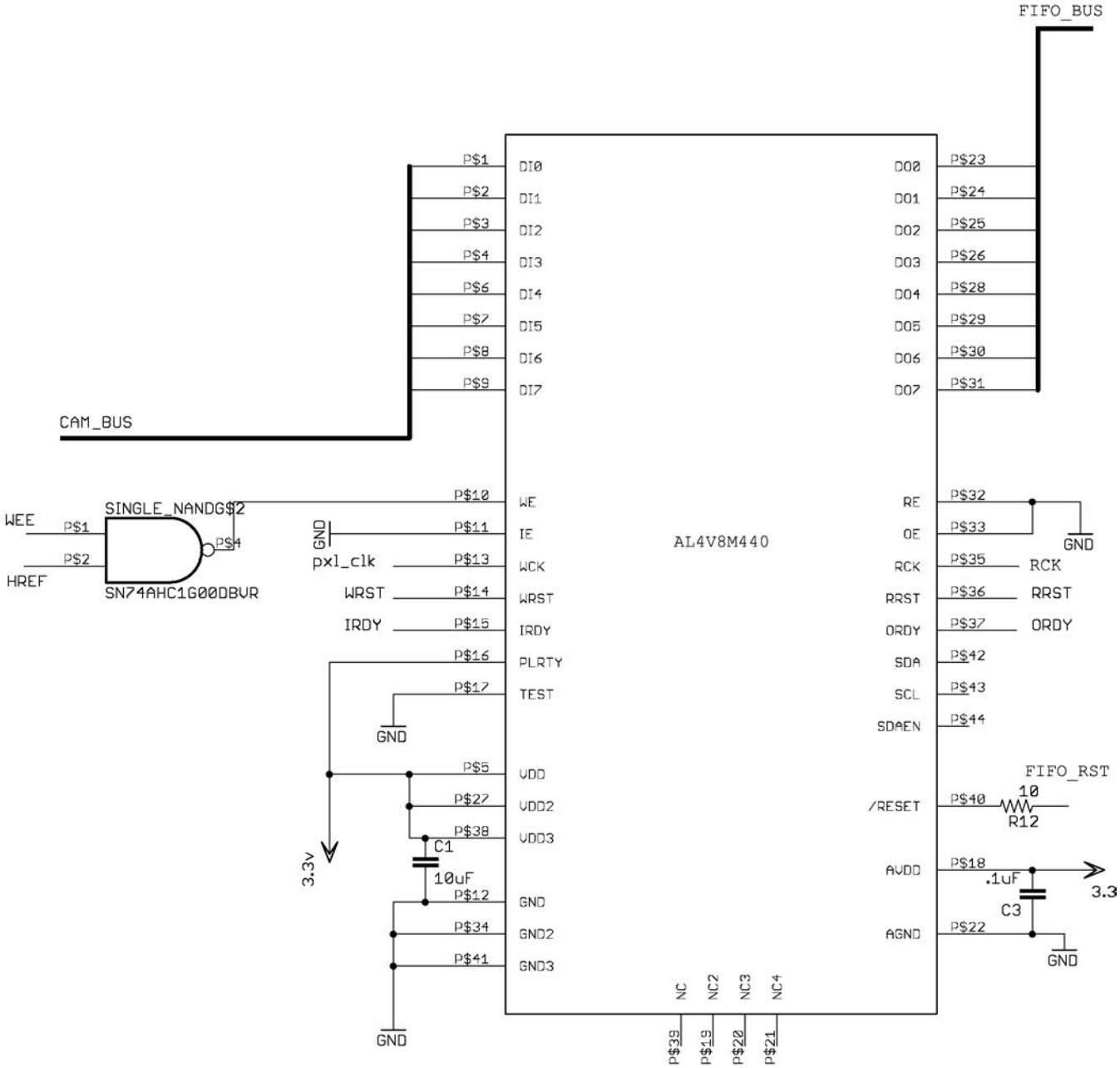
C1 50.54 30.78 0 10uF C0805
C3 46.70 14.64 0 .1uF C0603
C4 14.72 41.70 270 1.0uF C0603
C5 19.14 37.07 0 4.7uF C0805
C6 30.17 13.13 180 1.0uF C0603
C8 32.35 8.78 90 .01uF C0603
C19 29.83 8.94 90 .1uF C0603
C23 26.83 13.63 180 4.7uF C0805
C24 16.22 41.70 270 .01uF C0603
C30 33.50 4.42 90 .01uF C0805
C31 20.90 9.22 90 .1uF C0805
R4 20.65 16.13 0 1K R0603
R5 51.70 25.81 0 4.7K R0603
R10 51.70 23.16 0 4.7K R0603
R12 48.70 26.73 270 10 R0603
R13 20.65 19.91 0 1K R0603
R14 20.65 14.30 0 1K R0603
R16 20.65 18.01 0 1K R0603
R17 52.43 27.84 180 4.7K R0603
R18 42.70 32.08 0 4.7K R0603
SINGLE_NAND 44.22 19.61 270 SN74AHC SOT-23-5
SINGLE_NAND1 41.85 24.01 270 SN74AHC SOT-23-5
U5 40.33 46.88 180 ITT5777 ITT5777

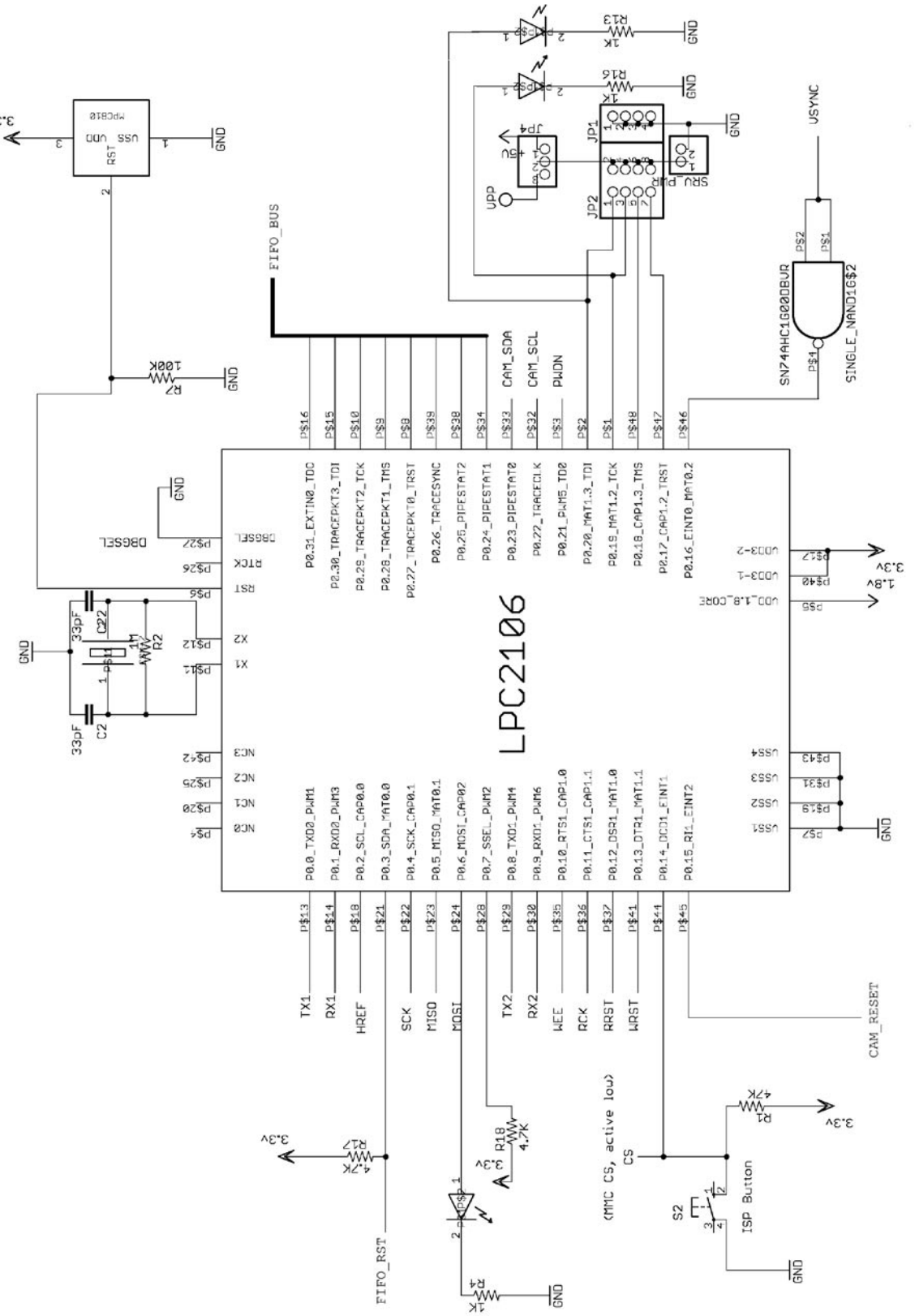
## Schematic

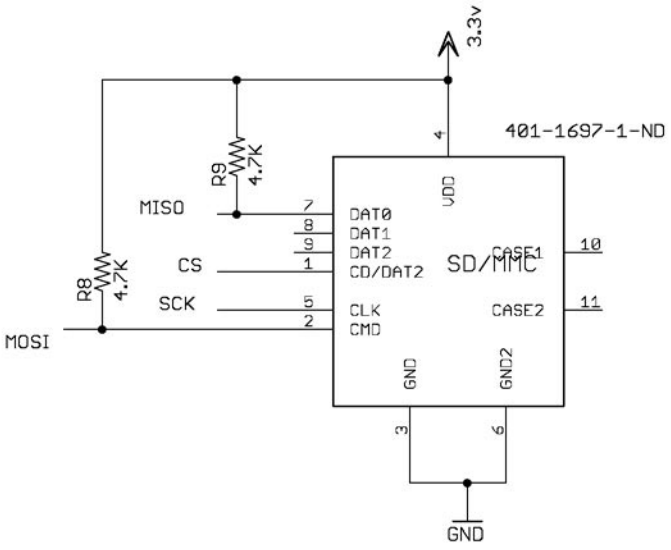

PWR_ENABLE
VPP
R15
4.7K
GND
4.7K
R3
VPP
PWR
S1
C31
.1uF
C27
15uF
C30
.01uF
REG102
VIN
ENABLE
VOUT
NR
GND
GND_TAB
P$1
P$2
P$4
P$5
P$3
P$6
+5V
C25
33uF
GND
+5V
IC1
TPS76333
IN
OUT
EN
ADJ
GND
1.0uF
C4
.01uF
C24
Do Not Install for TI reg
GND
3.3v
C5
MIC5213BM5
IC2
TPS76318
1.8v
1.0uF
C6
.01uF
C8
C23
4.7uF
Do Not Install for TI reg
GND
1.8v
.1uF
C19
GND
3.3v
.1uF
C15
.1uF
C16
.1uF
C17
.1uF
C18
GND
+5V
C20
33uF
C9
22uF
C10
1uF
C21
33uF
GND
3.3v
1K
R14
GND

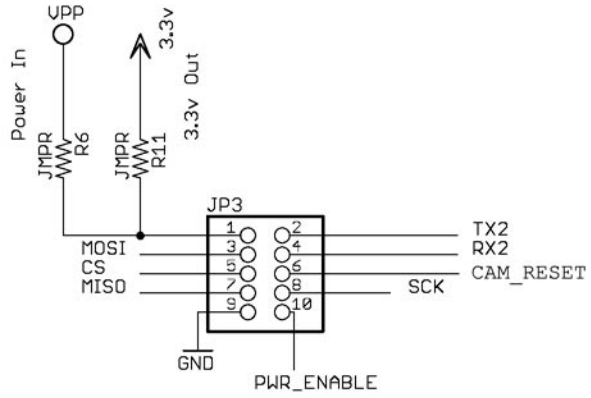

CAMERA_BUS
pwdn
CAM_SDA
CAM_SCL
CAM_REST
fodd / clk
href
vsync
pxl_clk
+5V
4.7K
R10
4.7K
R5
L3
1uH
C7
.1uF
AN_OUT
Analog Out
GND


MAX232D
C1+
C1-
C2+
C2-
VCC
V+
V-
T1IN
T2IN
R1OUT
R2OUT
T1OUT
T2OUT
R1IN
R2IN
GND
C26
C11
C12
C13
C14
1uF
RS232_BYPASS
UART_0
TTL_1
RX1
TX1

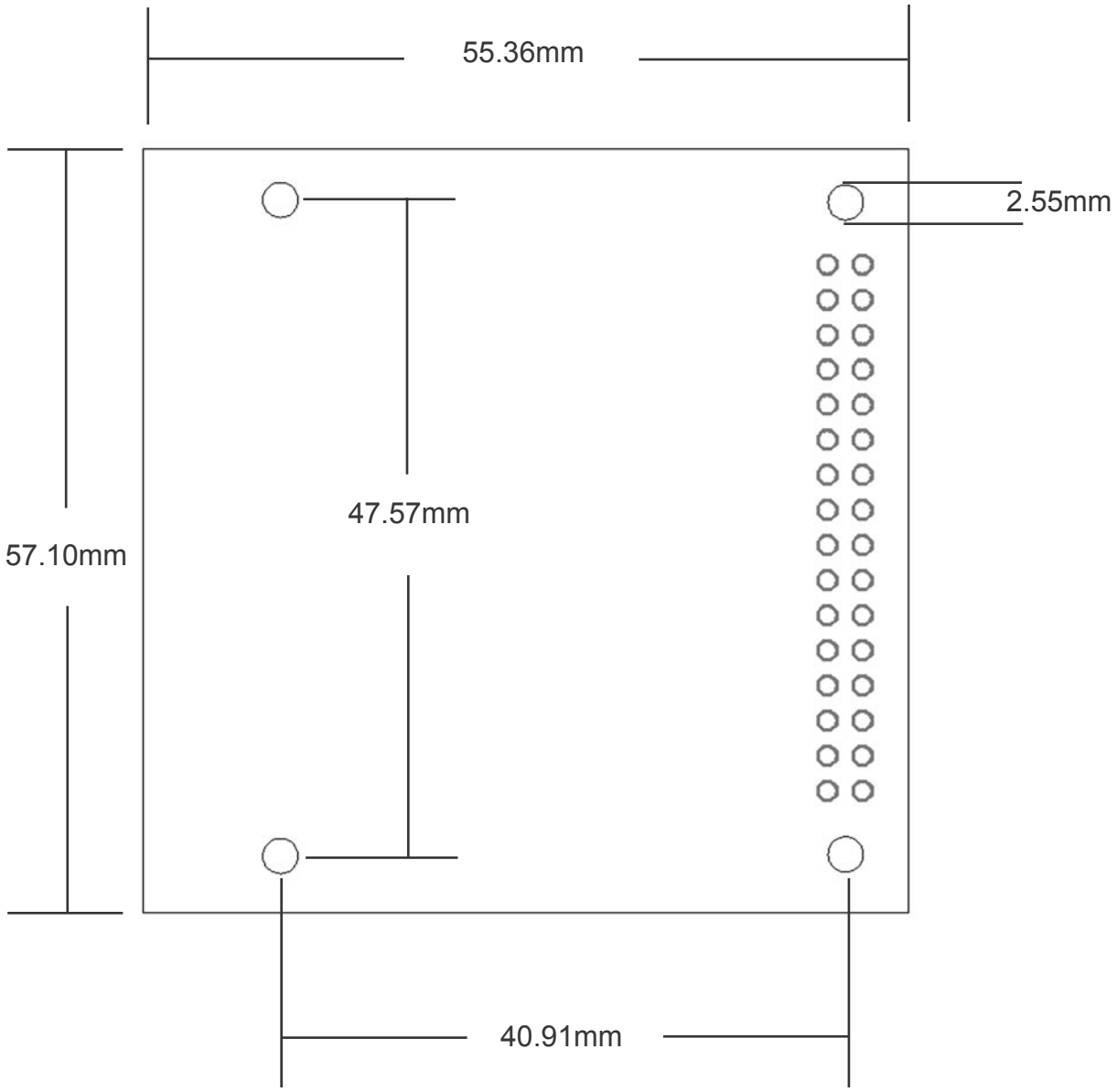

FIFO_BUS
CAM_BUS
AL4V8M440
DI0
DI1
DI2
DI3
DI4
DI5
DI6
DI7
DO0
DO1
DO2
DO3
DO4
DO5
DO6
DO7
WE
IE
WCK
WRST
IRDY
PLRTY
TEST
VDD
VDD2
VDD3
GND
GND2
GND3
NC
NC2
NC3
NC4
RE
OE
RCK
RRST
ORDY
SDA
SCL
SDAEN
/RESET
AVDD
AGND
SINGLE_NANDG$2
WEE
HREF
SN74AHC1G00DBVR
pxl_clk
WRST
IRDY
C1
10uF
3.3v
FIFO_RST
10
R12
.1uF
C3
3.3


LPC2106
FIFO_BUS
CAM_SDA
CAM_SCL
PWDN
VSYNC
CAM_RESET
FIFO_RST
SN74AHC1G00DBVR
SINGLE_NAND1G$2
ISP Button
(MMC CS, active low)
3.3V
1.8V
GND
100K
33pF
1M
TX1
RX1
HREF
SCK
MISO
MOSI
TX2
RX2
WEE
RCK
RRST
WRST
CS


3.3v
401-1697-1-ND
R9
4.7K
MISO
DAT0
DAT1
DAT2
CD/DAT2
SD/MMC
CASE1
10
R8
4.7K
CS
SCK
CLK
CMD
CASE2
11
MOSI
GND
GND2
GND


VPP
3.3v
Power In
3.3v Out
JMPR
R6
JMPR
R11
JP3
MOSI
CS
MISO
TX2
RX2
CAM_RESET
SCK
GND
PWR_ENABLE

## Dimensions



# 7. REVISION HISTORY

Version 1.01 August 7, 2007
- Fixed External Servo Power Connector Documentation
- Added Revision History

Version 1.02 September 22, 2007
- Fixed TTL serial pintout on page 6