CMUcam3 Datasheet

January 24, 2006

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Contents

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.

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
- 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
- Wireless Mote Networking Interface (Teleos 802.15.4)

* Camera Properties Depend on Camera Module
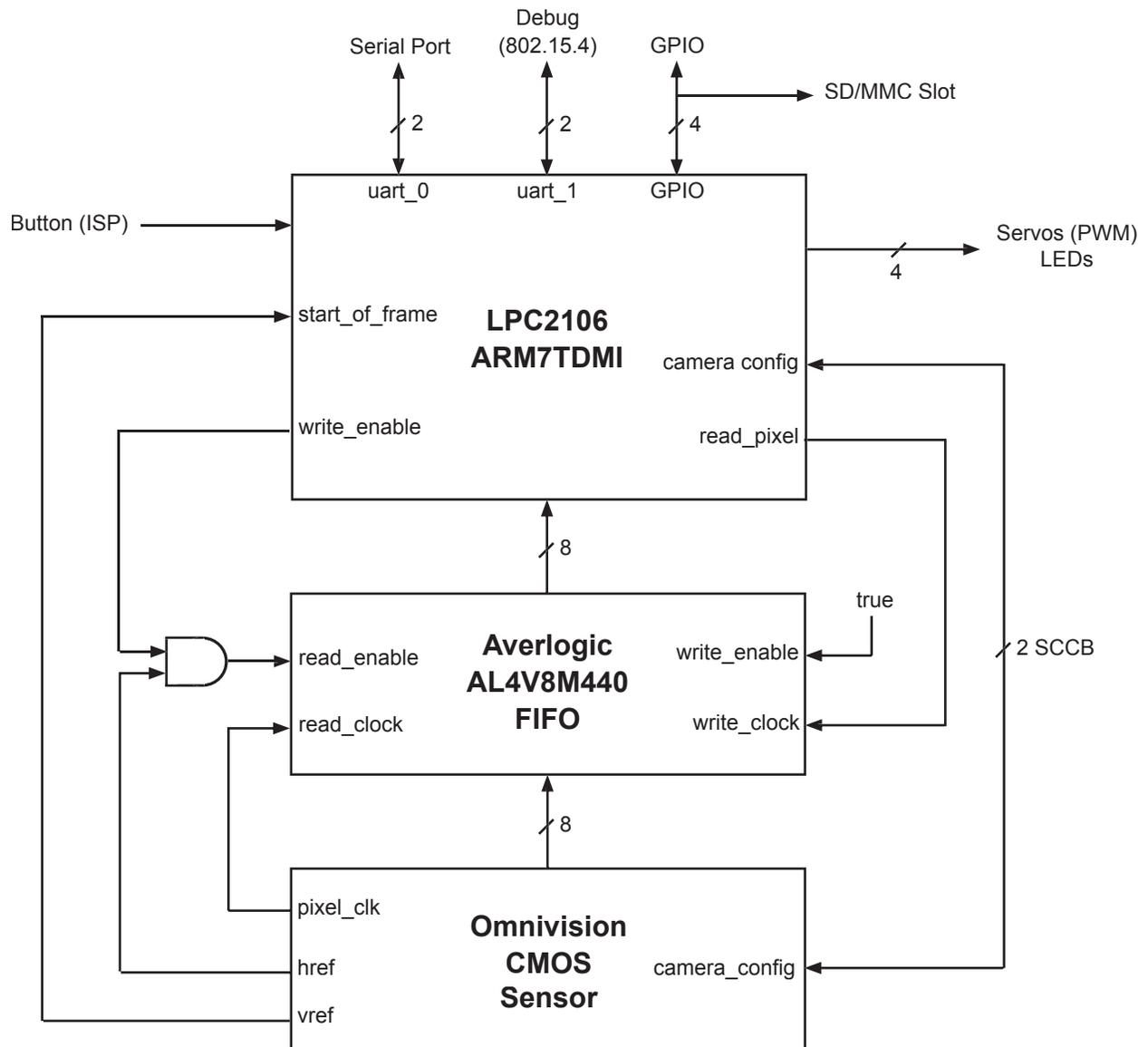
Embedded Vision Processor
CMUcam3

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

GPIO Header

Analog Output

Serial Port

TTL
Serial Port

Serial Bypass
Jumper

Servos Ports

Power Select
Jumper

Servo Power

Power

Camera
Connector

On   Off

LEDs   On/Off Switch   Button / ISP Enable

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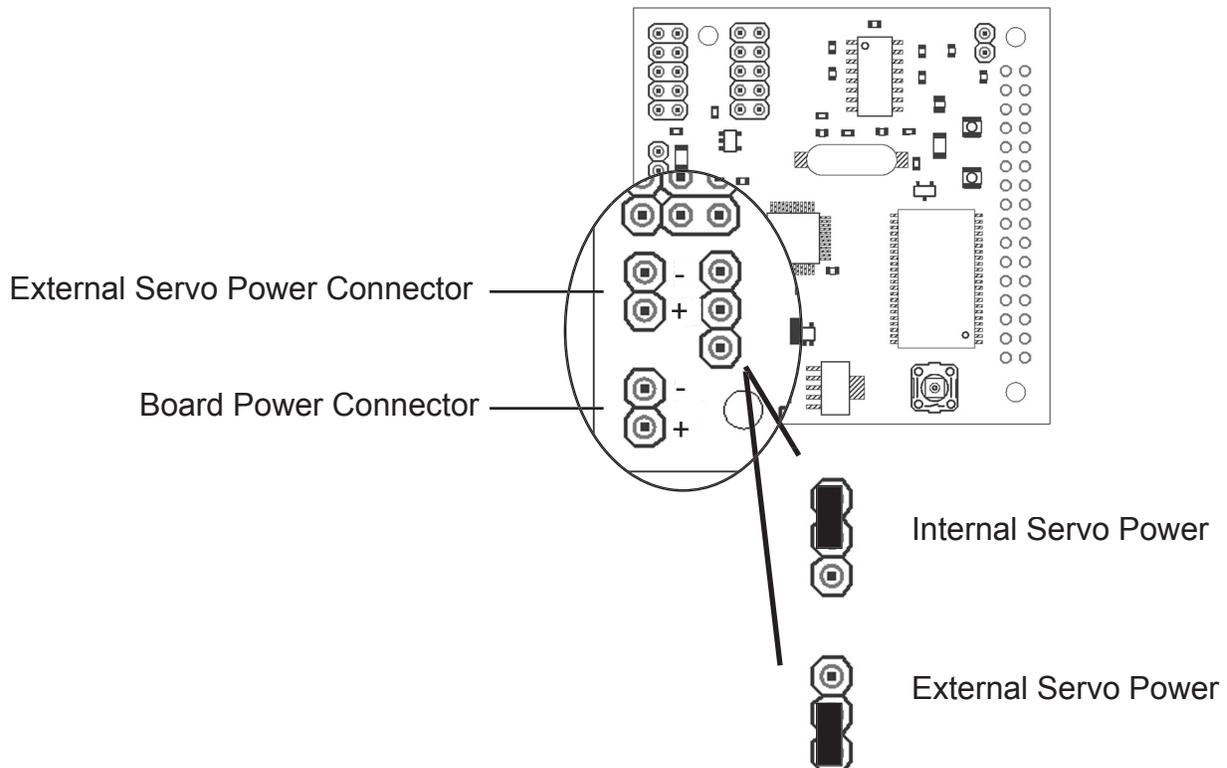
Power

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.
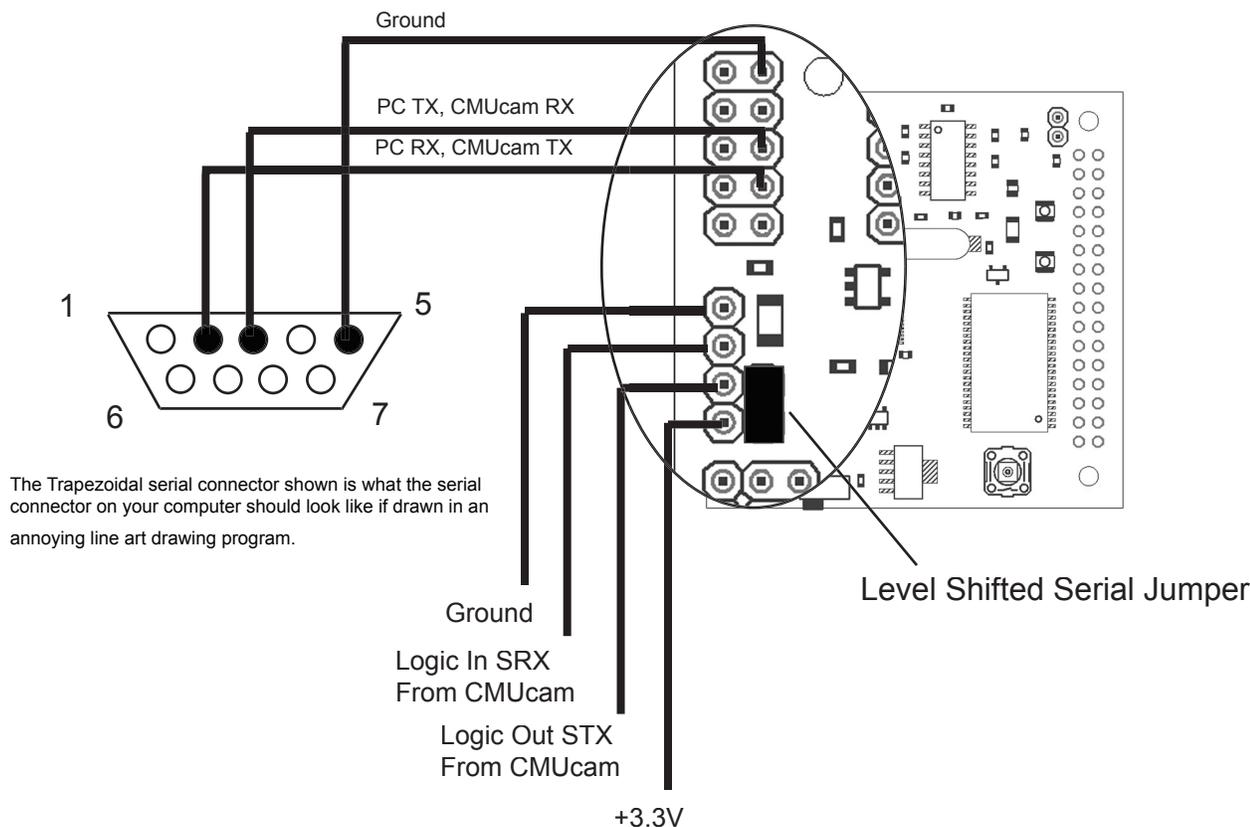
The servos can either be powered by internal power, or by the external servo power connector. To run them off of external power, add a jumper as show below in the "External Servo Power" position. Then connect your own servo power supply to the "External Servo Power Connector". To run off of internal 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.
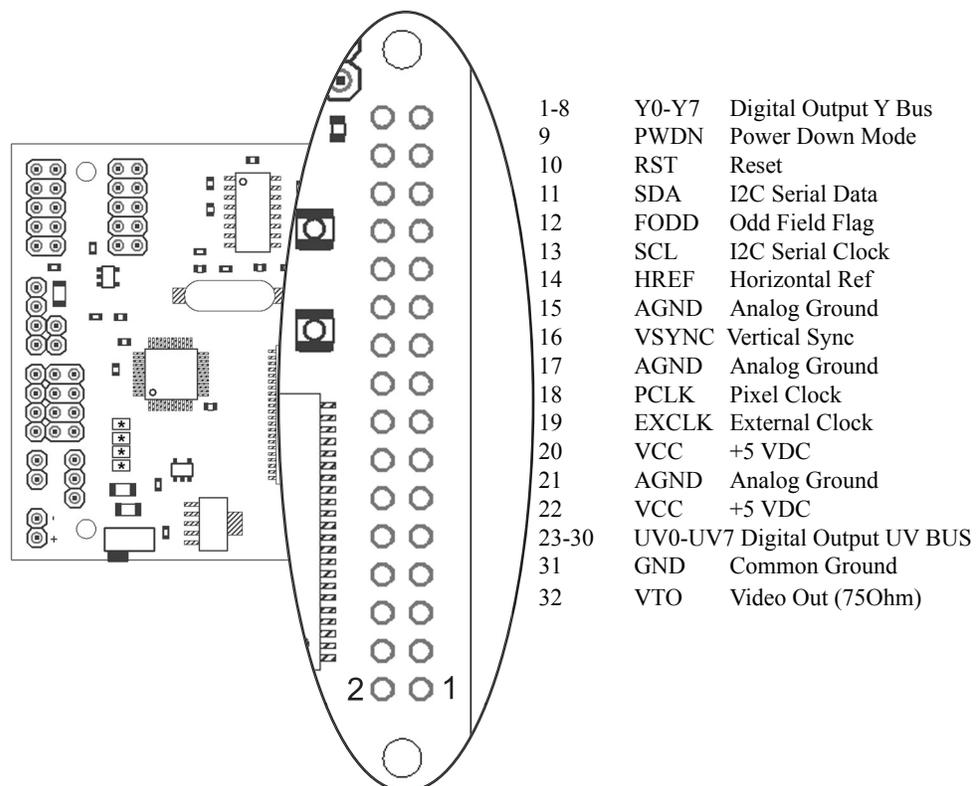
Serial Port

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. It operates between 0 and 5 volts. Remove the Serial Jumper when you use this mode.

The Trapezoidal serial connector shown is what the serial connector on your computer should look like if drawn in an annoying line art drawing program.
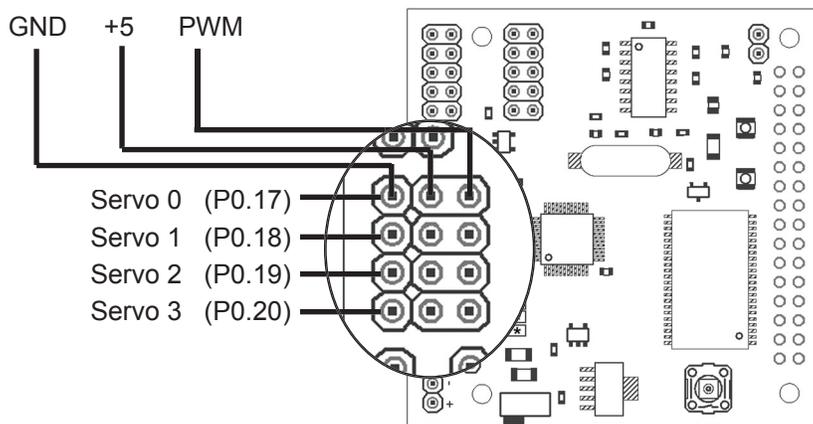
Camera Bus

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.

Pin	Name	Description
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.

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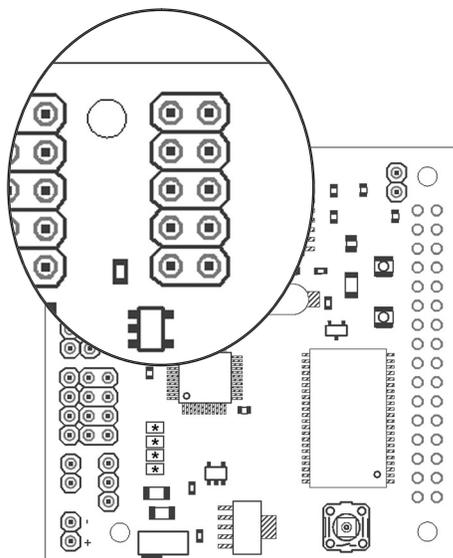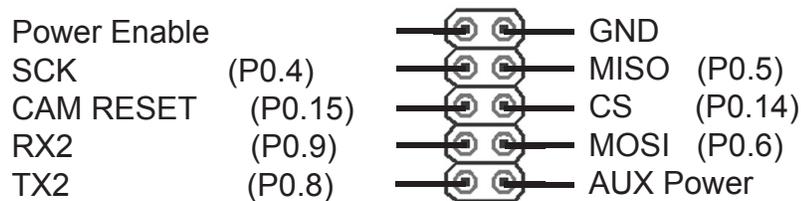
Expansion Port GPIO

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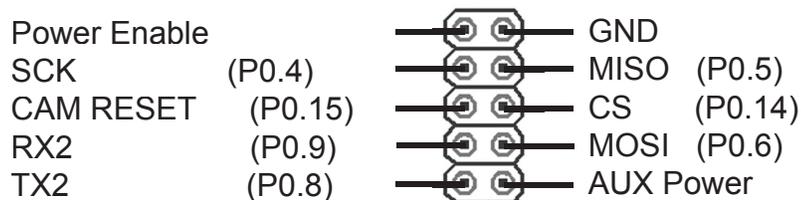
RX2 - The receive pin on UART2 is not level shifted and hence can not be directly connected to a PC or none TTL external device. This pin can also be used as GPIO.

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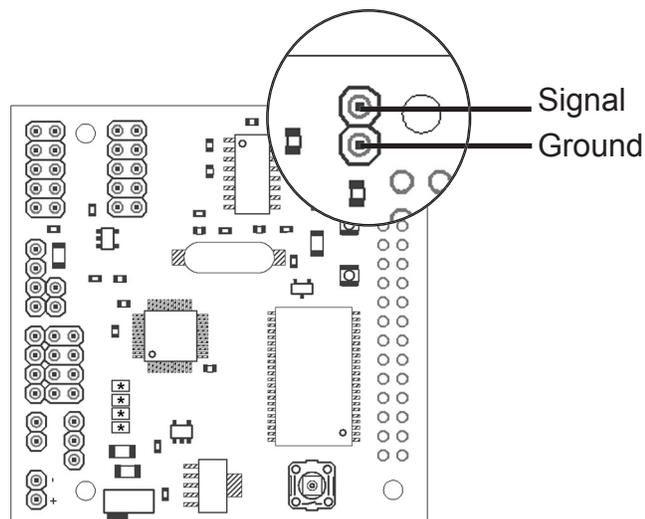
SCK - Normally this pin is controlled by the MMC driver. This pin can also be used as GPIO or as the SPI clock pin when an MMC card is not inserted.

Power Enable		GND	
SCK	(P0.4)	MISO	(P0.5)
CAM RESET	(P0.15)	CS	(P0.14)
RX2	(P0.9)	MOSI	(P0.6)
TX2	(P0.8)	AUX Power	

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.
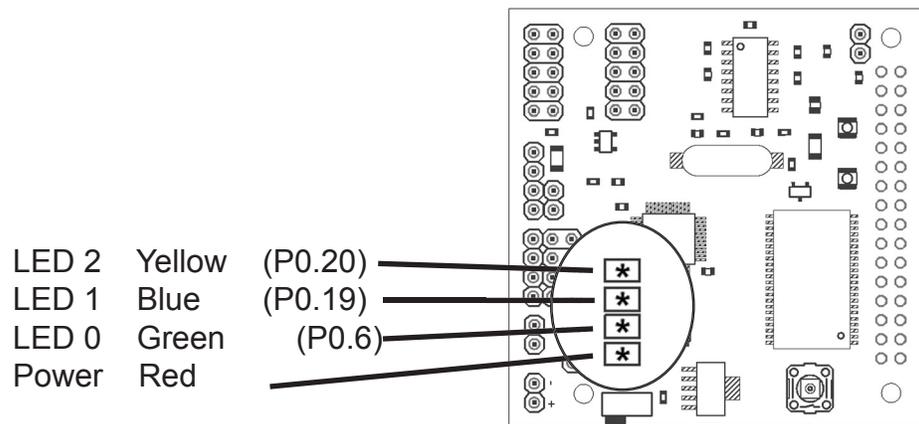
LEDs

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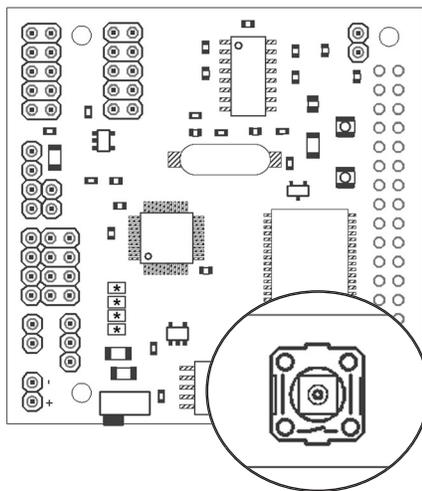
LED 1 - This pin is shared with the Servo 2 pin. When using Servo 2, the LED will flash.

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

LED 2   Yellow   (P0.20)
LED 1   Blue   (P0.19)
LED 0   Green   (P0.6)
Power   Red

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.

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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.cs.cmu.edu/~cmucam) or the Philips website.
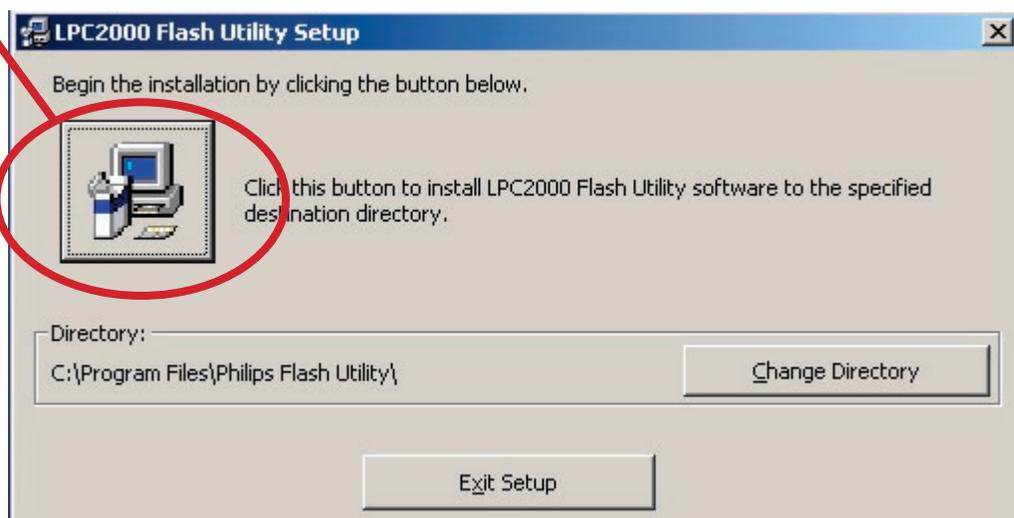
http://www.semiconductors.philips.com/files/markets/microcontrollers/philips_flash_utility.zip

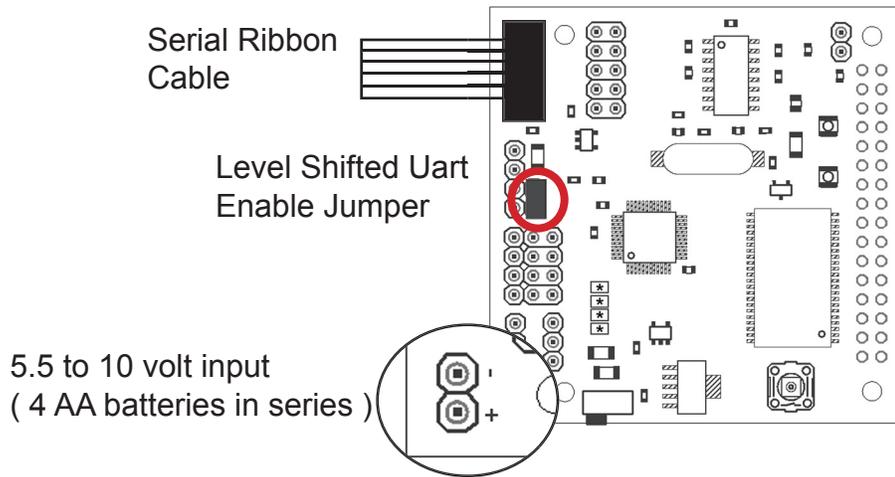2) Double Click on the "philips_flash_utility.zip" icon.

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

Serial Ribbon
Cable

Level Shifted Uart
Enable Jumper

5.5 to 10 volt input
(4 AA batteries in series)

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:

Click to Select Firmware File

Select Com Port and Set Baudrate to 115200

Select "LPC2106"

Make sure this is set to "14745"

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.

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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.

Power Switch   ISP Button

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.

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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.cs.cmu.edu/~cmucam3/downloads.html

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.
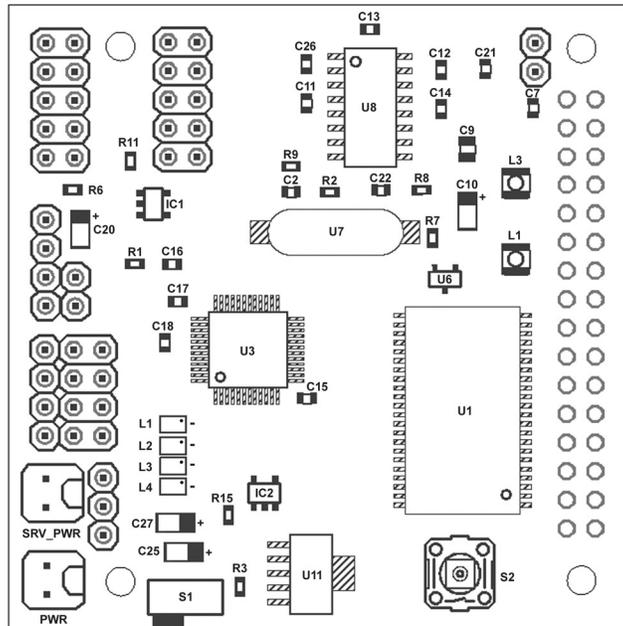
Once installed, here is a set of sample command line arguement for downloading:
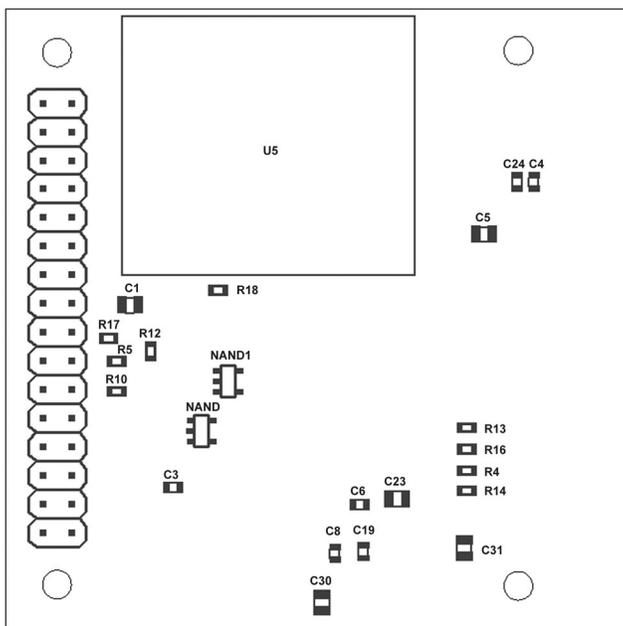
>: cd CMUcam3/projects/hello_world
>: lpc21isp hello_world_lpc2106-cmucam3.hex /dev/ttyS0 115200 14745

6. ASSEMBLY INFORMATION

Top Placement

Bottom Placement

Note: Camera Bus Header on Bottom of Board.

Dimensions