Z-Goggles

Multi-function Vision System

Group 1
C.J. Silver
Geoff Jean
Will Petty
Cody Baxley

What are Z-Goggles?

- Vision Enhancement System
- 3 cameras – Visible, IR, UV
- Image change functions – Shift, Drunken Vision, Photo-negative, Spectrum Shift
- Function control via UI controller
- Portable, helmet-mounted screen
- Battery-powered

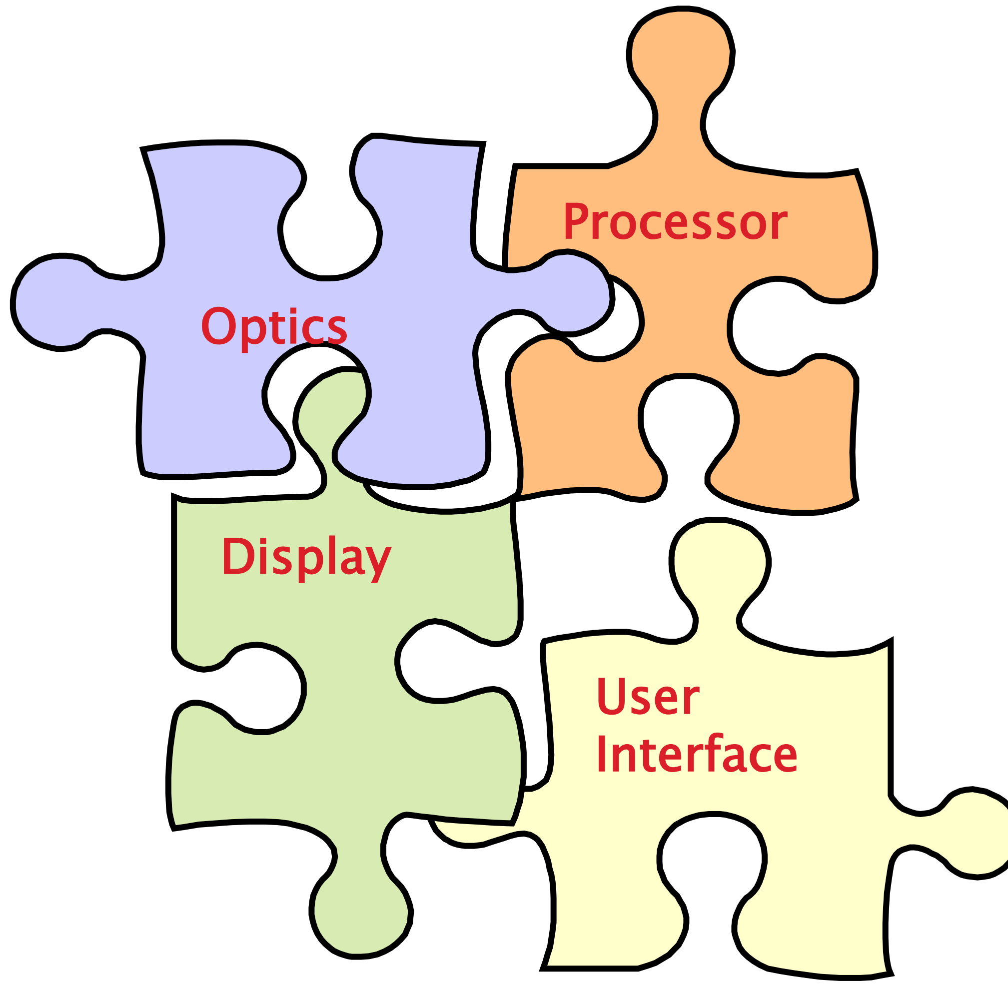
Goals and Objectives

- Cost-effective engineering
  - Low cost components requiring more work
- Portability
  - Battery and backpack/helmet system allows movement
- Simple to use
  - Simple UI controller for video mode and functions
- Effective video processing and display
  - Minimize choppiness by maximizing processing speed via parallel logic implementation

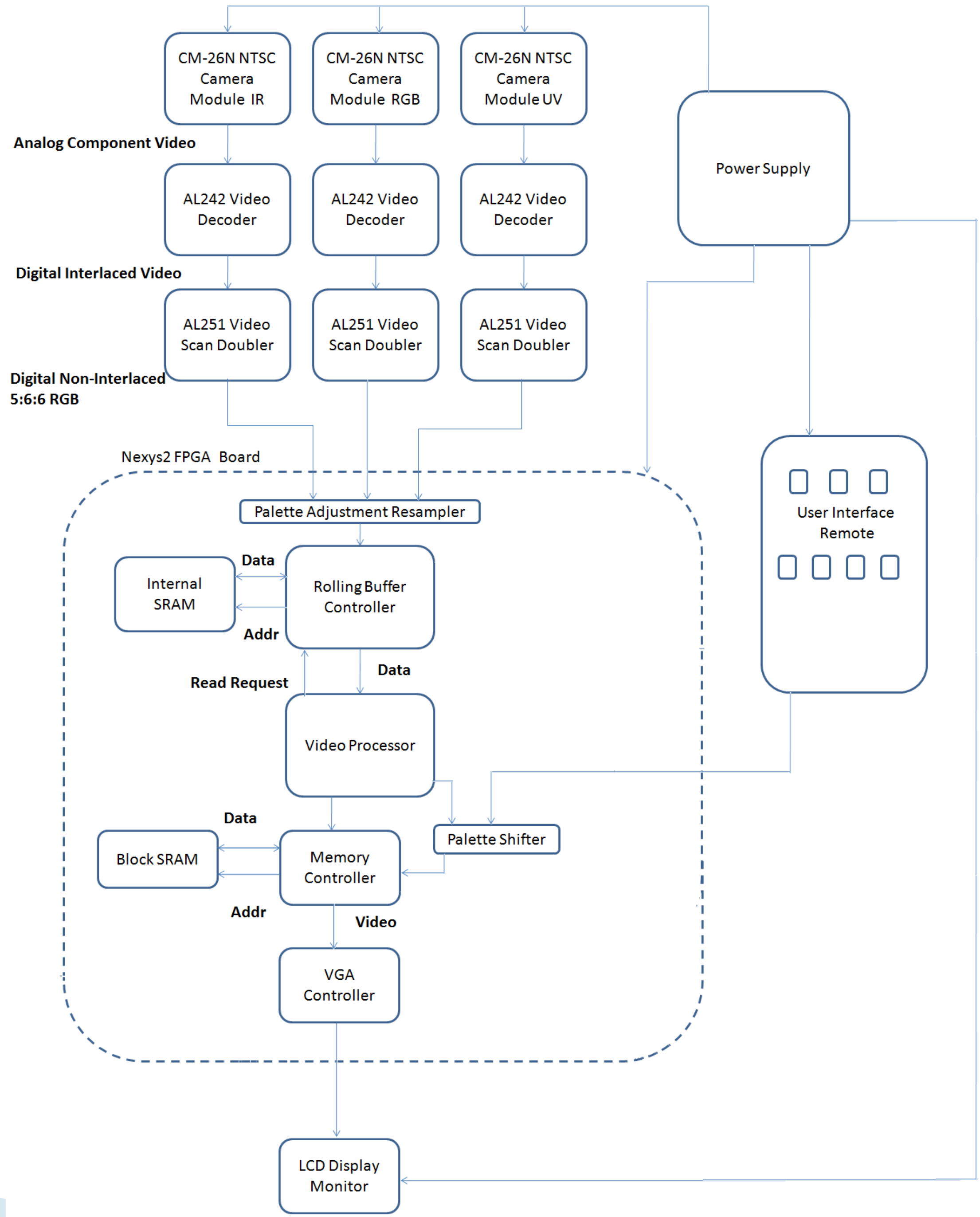
Design Approach

Separate systems – Integrated at later stages

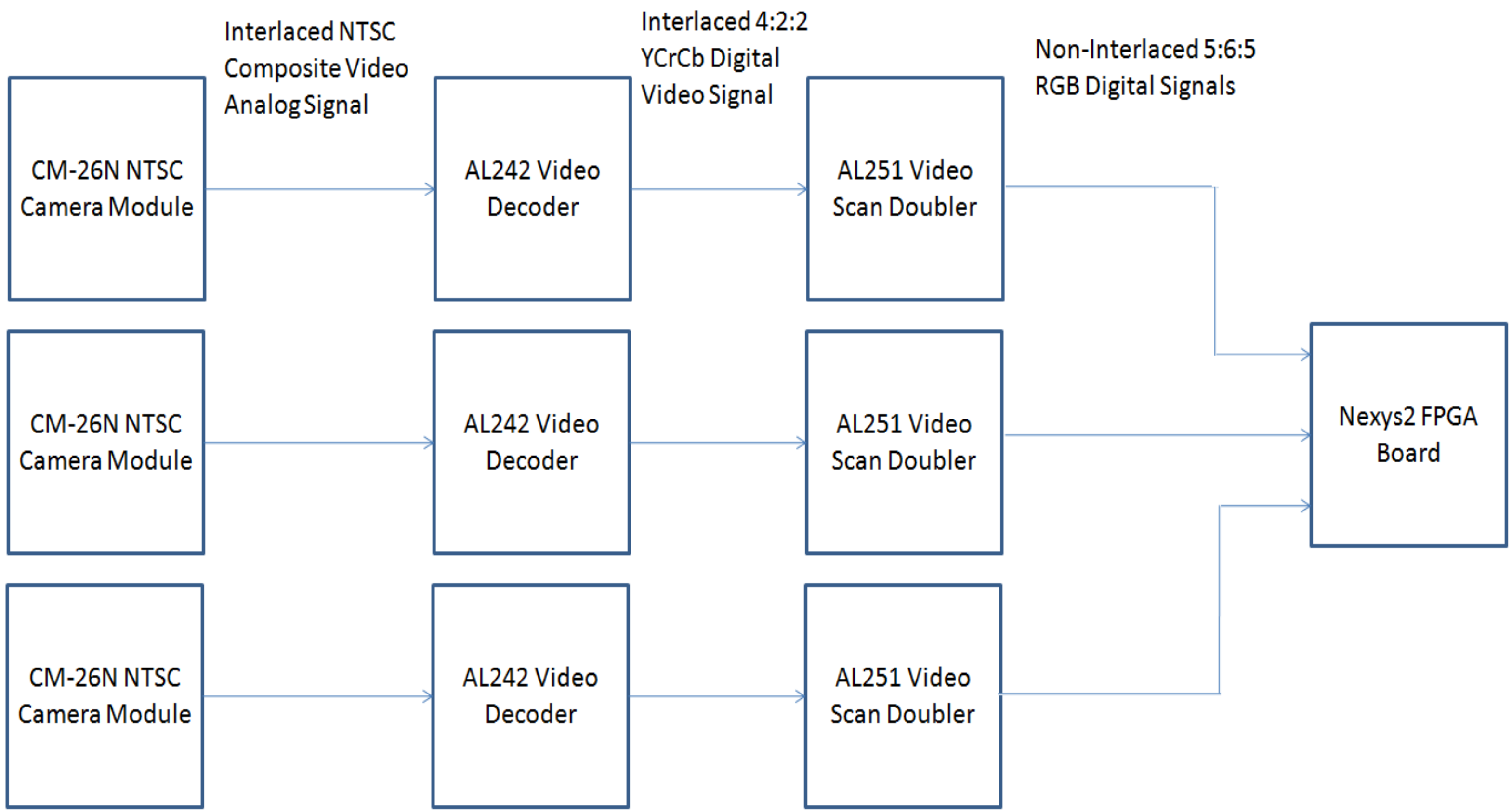
- Optical System
- Video Processor
- Display
- User Interface
- Power supply



Overall Project Diagram



Optical System overview



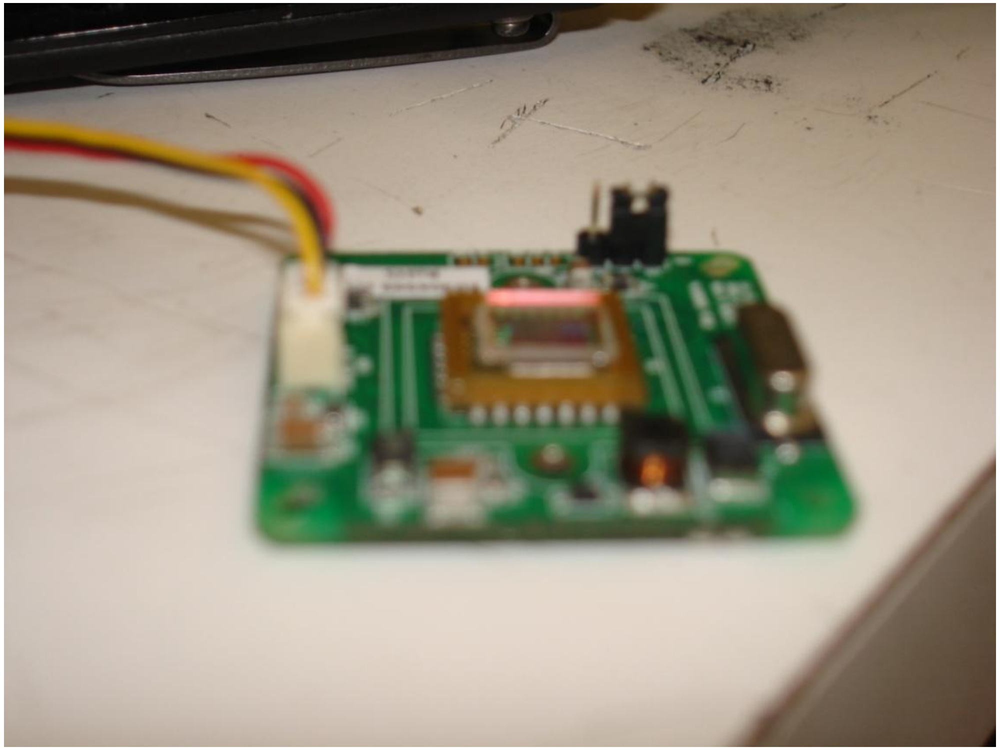
Optical System Specs and Reqs

- The unit shall contain three cameras to capture live video data.
- One camera will be filtered normally to allow color video. One camera will be filtered with a UV pass filter to allow UV video. The final camera will be filtered with an IR pass filter to allow IR video.
- Cameras resolution will be at least 320 x 240, up to 640 x 480.
- The Optical System will output RGB or YUV data in a usable or convertible size (8bit is the target for the Video Processor).
- The system shall be capable of achieving at least 15 fps (30 preferred).

Design Decision– Webcam issue

- Initial design concept used Logitech C200 webcam for cameras
- Discussion with Logitech technical support revealed necessity to create a dummy Windows driver to run cameras
- Reverse engineering the driver to decode the USB information was deemed too time intensive – thus the move to the CM-26N

Checking IR filter



- Opened camera and determined an IR filter was present
- Filter will be removed and replaced with Wood's Glass for the UV cam, and photo negative film for the IR camera.

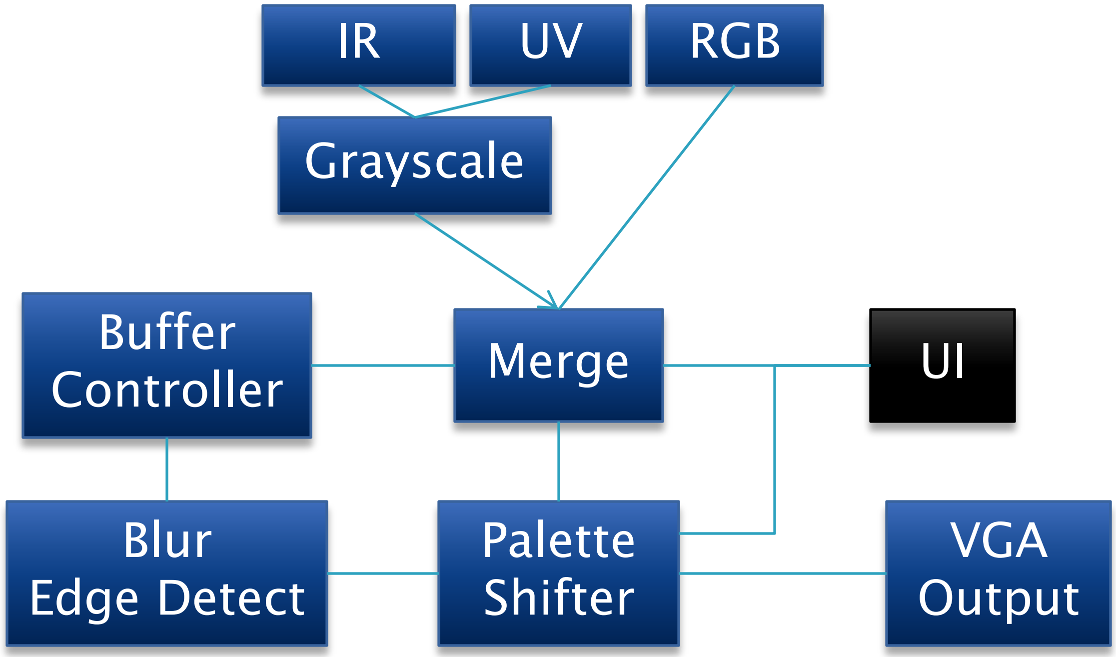
Difficulty – NTSC camera not working

- No image found within the output, though color changes slightly when objects are moved into view.
- Camera is experiencing sync signal issues.
- Connections are properly grounded and powered.
- Tested on multiple televisions, old and new.

Design decision – Camera Replacement

- Due to issues, decided to check other cameras.
- Found a digital output camera that has the specifications we need, the C3188A, based on OV7620 sensor from OmniVision.
- 16/8 bit output RGB or YUV, or monochrome composite for testing.
- Programmable through I2C interface.

Video Processor overview



Design decision – Platform (DSP vs. FPGA)

- FPGA
  - Scattered support of operations
  - Time-consuming implementation
  - Timing guarantees
  - Cheap development environments
- DSP
  - Strong compiler and toolchain support
  - Fast linear multiply/add
  - Greatly simplify implementations of 2d transforms
  - No guarantee of timing/throughput

Design decision – Which FPGA used, why?

- S3BOARD
  - 1Mb onboard asynchronous SRAM 10ns access time
  - 500MHz max internal clock speed
  - Too few GPIO pins for 16-bit inputs
- Nexys2
  - 8bpp Video
  - Lots of GPIO pins
  - Higher gate count

Video Processor Specs and Reqs

- 640x480 30fps 8/16bpp
- Pixel process time: 108ns
- Multiply/Add time <20ns
- Buffer Read at least 3x faster than pixel clock
- FIFO based system
- Dual-buffer cache system
  - 3 video lines of storage for transforms
  - 3x3 storage element to reduce memory load

Success – Subsystem Construction

- Optimization of edge detection with Sobel Operator
- Optimization and proof for integer blur
- Buffer controller design
- Video output controller

Design – Edge Detection/Blur

A	B	C
D		E
F	G	H

−1	0	1
−2	0	2
−1	0	1

−1	−2	−1
0	0	0
1	2	1

Gx=(H−A)+(F−C)+(G−B)<<1
Gy=(H−A)+(C−F)+(E−D)<<1
G=|Gx|+|Gy|

X	X	X
X	Y	X
X	X	X

(2^Z)(2^(X+3)+2^Y)=1

−4	−1	0
−3	0	−1
−2	1	−2
−1	2	−3
0	3	−4

Difficulty – Possible Timing problems

- Synchronization of video frames
- Merge latency
- Data sampling
- I2C control translation between UI and camera

Display Specs and Reqs

- The unit's display system shall be capable of displaying at least 15 fps (30 preferred).
- The unit's display system shall be VGA compatible for easy interfacing.
- The unit's display system shall be mounted approx 6" from the user's face, and enclosed in a manner that allows the user to focus on the screen.
- The unit's display system will be capable of outputting a resolution of 640x480.
- The unit's display system shall receive valid frame data via a VGA controller on a FPGA board.

Design decision – PSone screen vs. others

LCD Screen	Resolution	Connection	Price
Crystalfontz CFAF320240F-T	320x240	QVGA	$51.16
Sharp Microelectronics LS037V7Dw01	640x480	VGA/QVGA	$150+
SCPH-131 Sony Playstation	640x480	AV in	$55

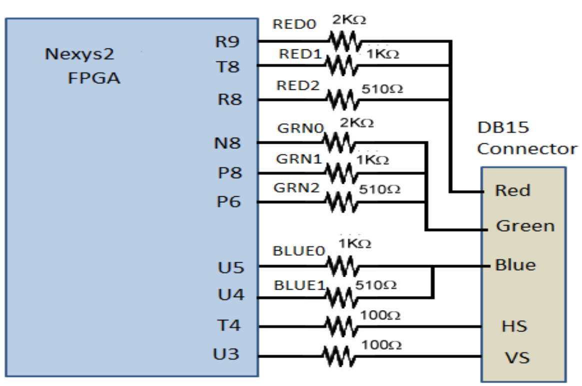
VGA Interface

Software: VGA Controller:

- Signal Timing:

Format	Pixel Clock (MHz)	Horizontal (in Pixels)				Vertical (in Lines)			
		Active Video	Front Porch	Sync Pulse	Back Porch	Active Video	Front Porch	Sync Pulse	Back Porch
640x480, 60Hz	25.175	640	16	96	48	480	11	2	31

- Output Signals:



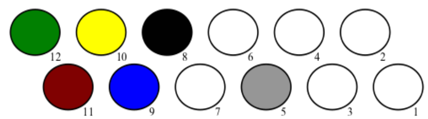
VGA Interface

Sony LCD screen needs to be modified to support VGA connection

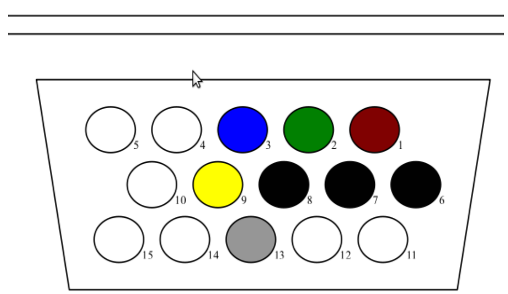
Pin layout of VGA connector

PIN	PIN Signal
1	RED Red video
2	GREEN Green video
3	BLUE Blue video
5	GND Signal ground
6	RED_RTN Red ground
7	GREEN_RTN Green ground
8	BLUE_RTN Blue ground
9	VDC 5 VDC supply (fused)
13	HSYNC Horizontal sync

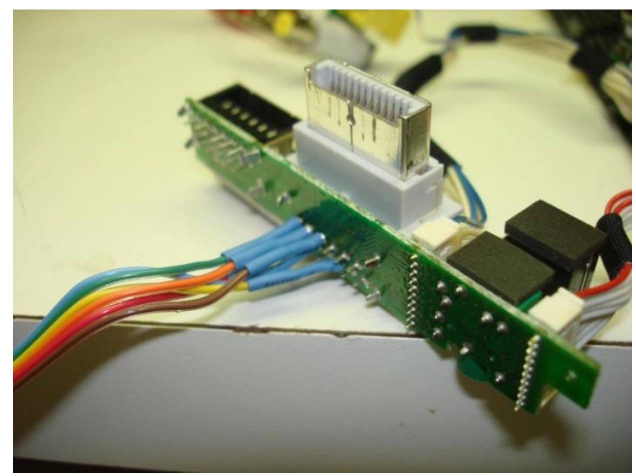
Solder points from VGA connection



PSOne Header Wiring (Solder Side)



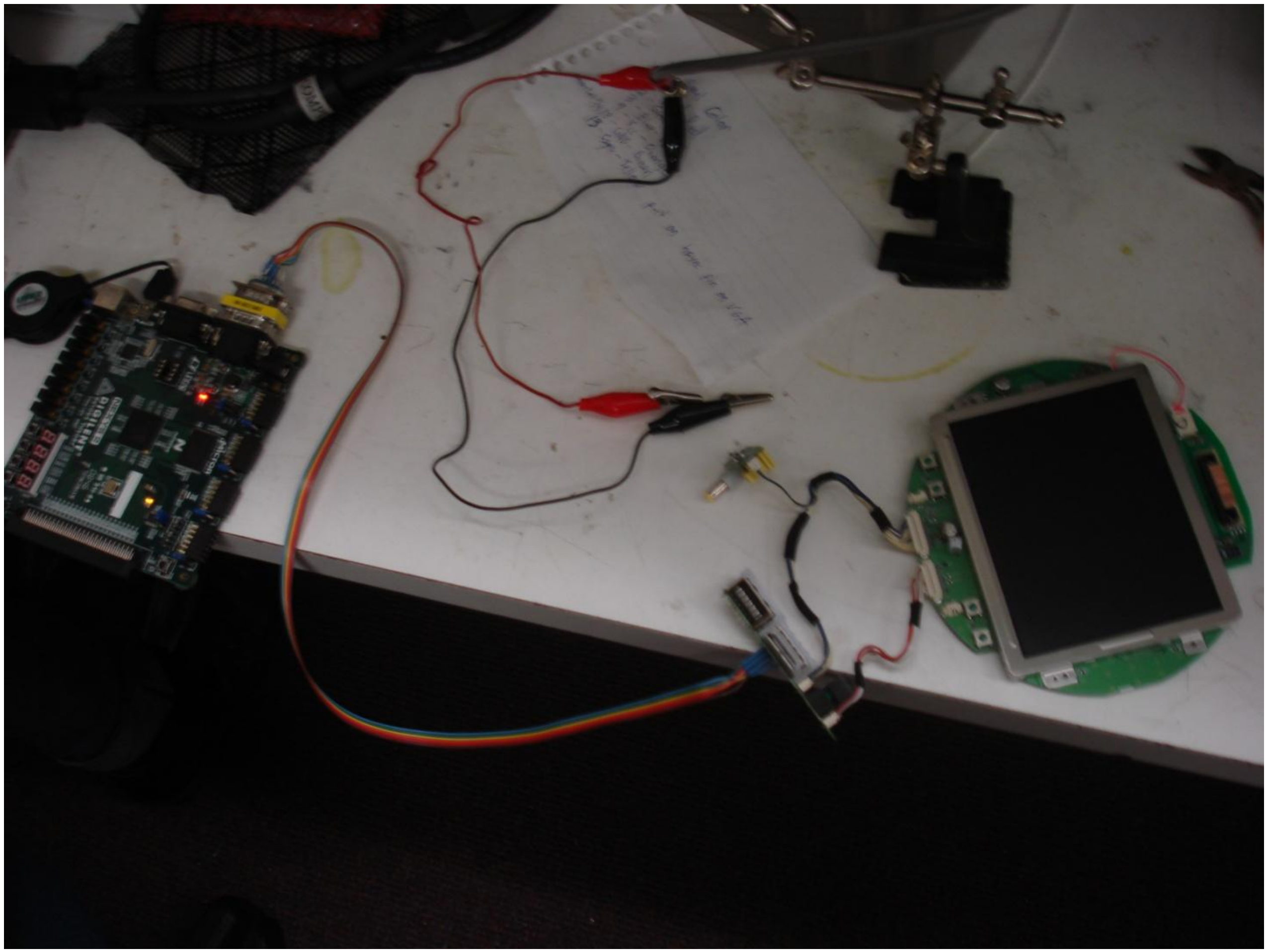
VGA Pin Wiring (Solder Side)



Display work for prototype

- Programmed an 8-bit VGA controller in Verilog
- Soldered the connecting wires of the VGA output cord to the correct pins on the screen
- Assembled working VGA connection cord with ribbon wire and the correct DB-15 connector
- Tested the output of screen with VGA controller on FPGA

Display System Prototype



Display Screen Difficulties

- Composite Sync Pulse timing problems
  - Not a XOR of Vertical and Horizontal Syncs

- Backlight LED issues
  - Never worked; Need to be replaced

- No Datasheet
  - Hard to find consistent information

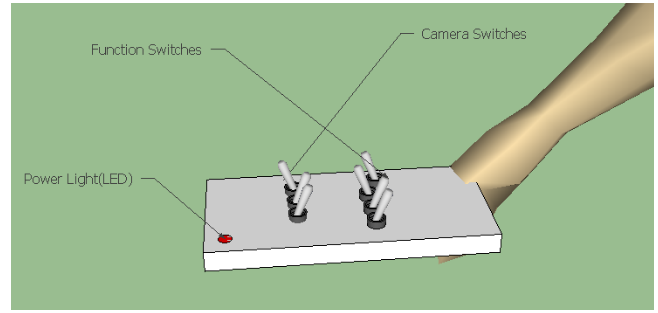
UI Specs and Reqs

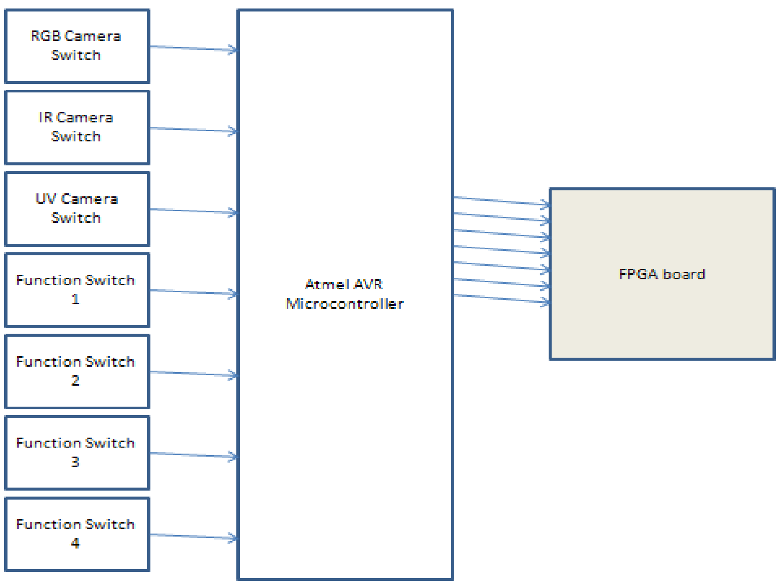
- An ATMega168 microcontroller will be uses to control the user interface.
- The system's user interface shall be contained in a switch box remote
- The system's user interface shall contain one switch for each individual camera and function
- The user interface software shall allow for multiple functions when feasible, and deal with multiple function switches when not.
- The user interface software shall allow for easy modification should multiple camera image fusion become feasible.

User Interface overview

User Interface Remote Control

- Three Camera Switches
- Four Function Switches
- Power Light (LED)





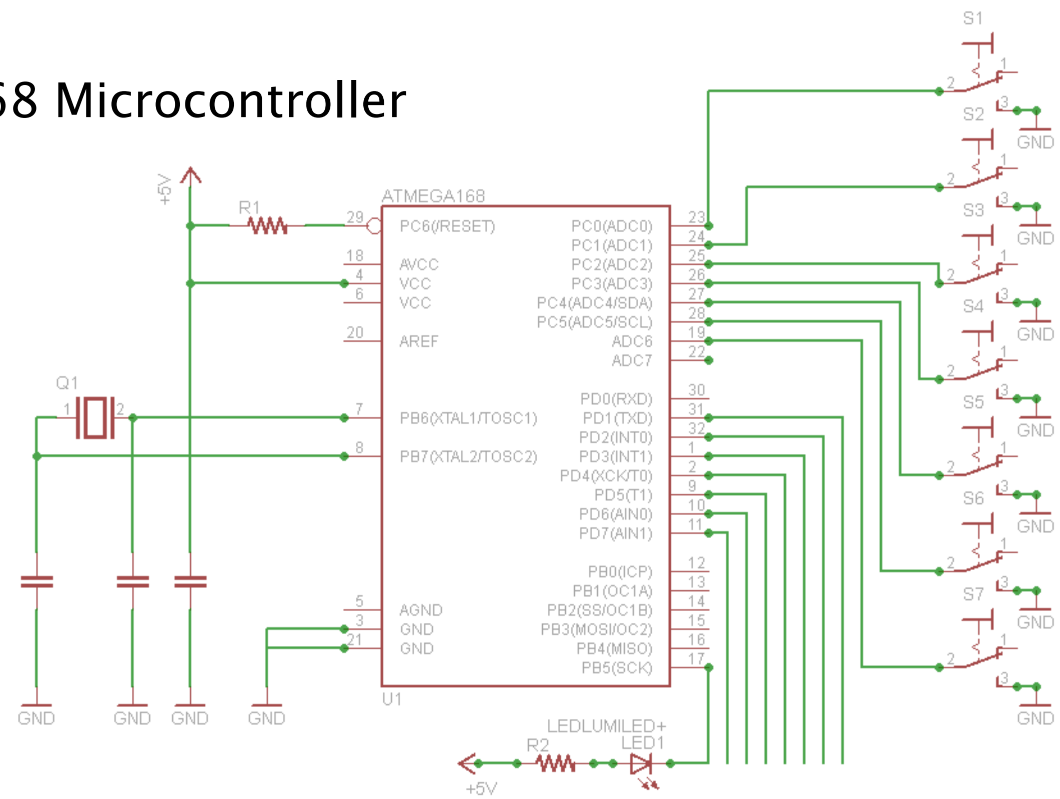
Microcontroller/ FPGA Interface

Directly Connected Signals

- Simple 7 High/Low Signals
- Plenty of Open Pins on FPGA

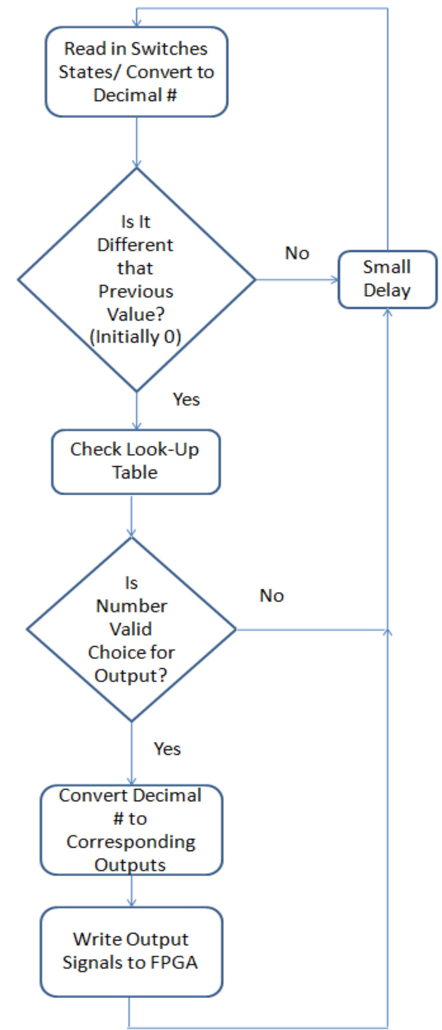
User Interface Hardware Design

ATmega168 Microcontroller



User Interface Software Design

0	0	1	0	0	0	1
C1	C2	C3	F1	F2	F3	F4



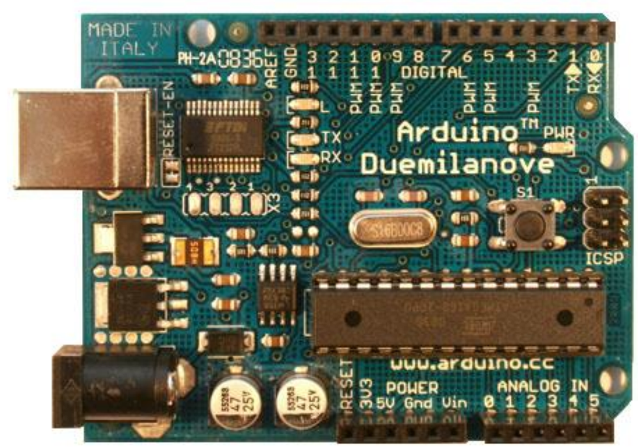
Look-UP-Table
•Array of 128 possible choices
•Valid choice =1, Invalid choice = 0

Reason for Design
- Goal is to allow for any possible combination of Cameras and Functions
- Current design allows for easy modification of any choice to be allowed or not

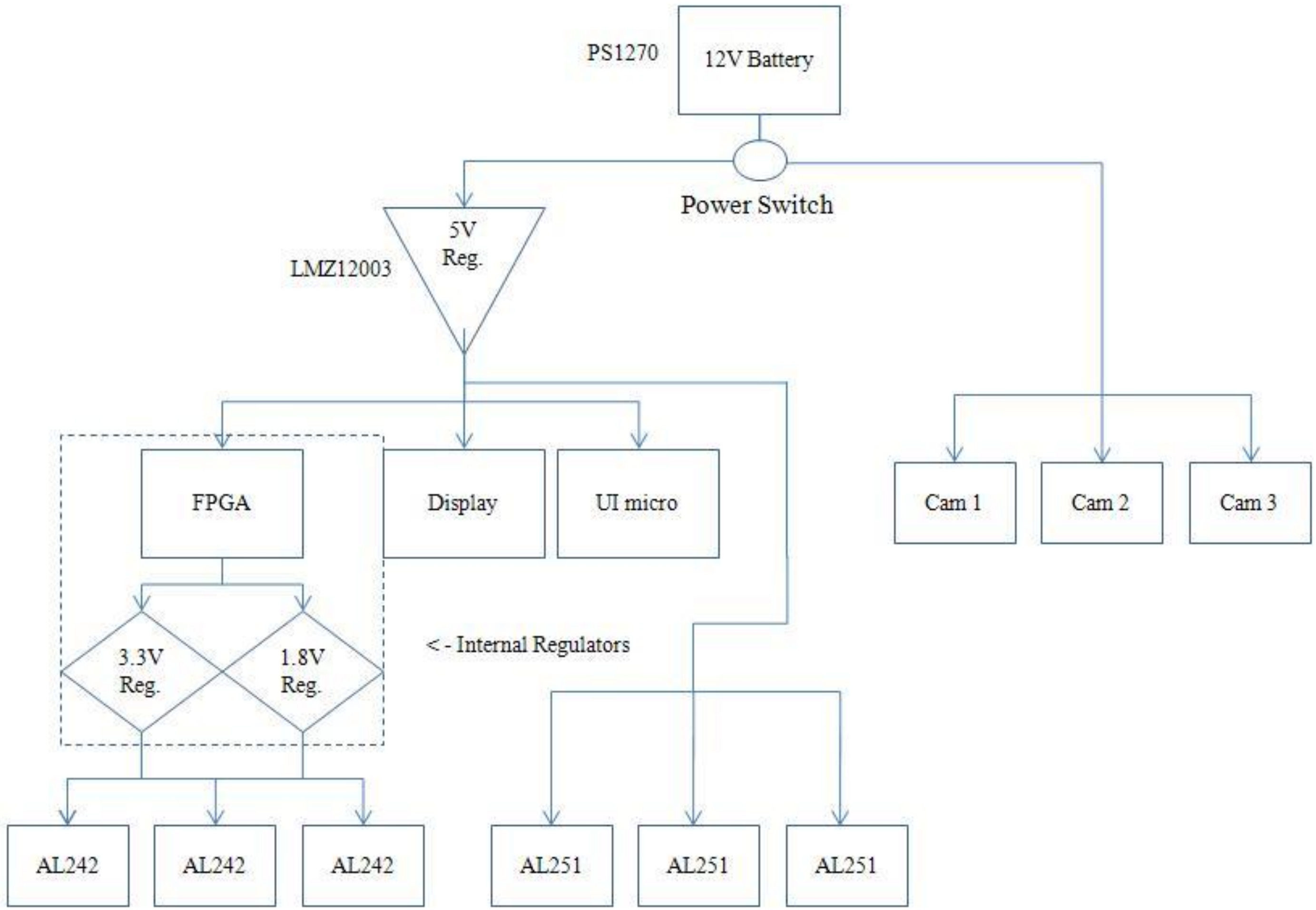
User Interface Development Tools

Arduino Duemilanove board

- Easy Java-like Wiring language
- Free Open Source Software
- USB Programmable
- Free, We already had one!



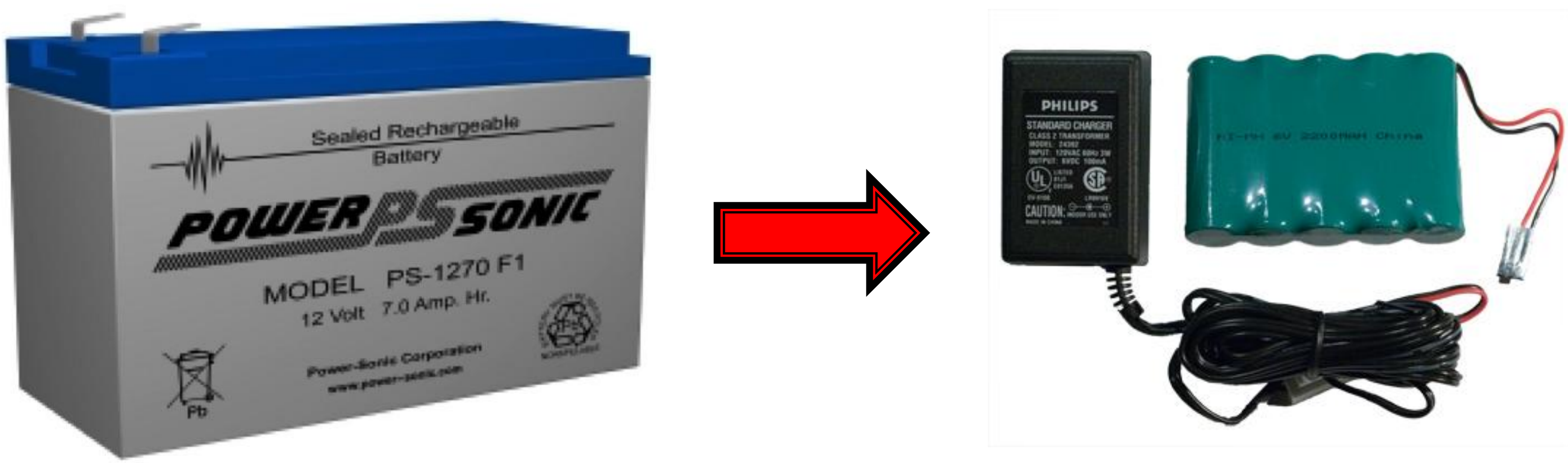
Power Supply Overview



Power Specs and Reqs

- The unit shall have a portable power supply, such as a type of battery.
- The unit shall provide power outputs of 12 Volts and 5 Volts.
- The power source shall be safely placed in the backpack, and any power lines that are run outside will be covered safely.
- The power source shall have storage capacity capable of running the system for 2 hours.
- The power supply shall have an On/Off switch to shut the system off.

Battery



- Original battery chosen: 12 Volt, 7 Amp hour, Lead Acid
- Could be replaced with a new battery for final system; new cameras only require 5V input.
- New battery will likely be 6 Volt, 2.2 Amp hour, NiMH; this will cause a shorter use-time, but it is lighter and cleaner.

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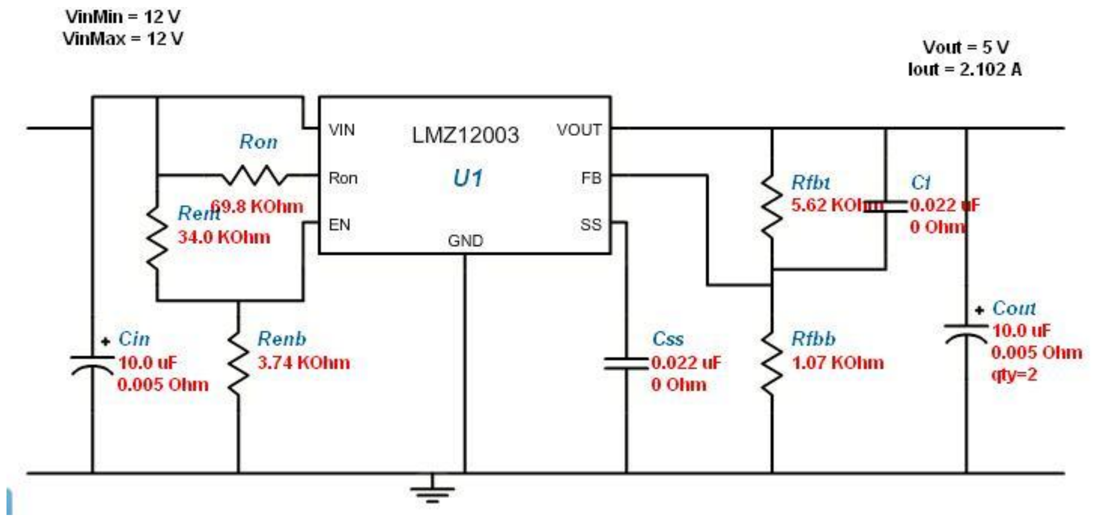
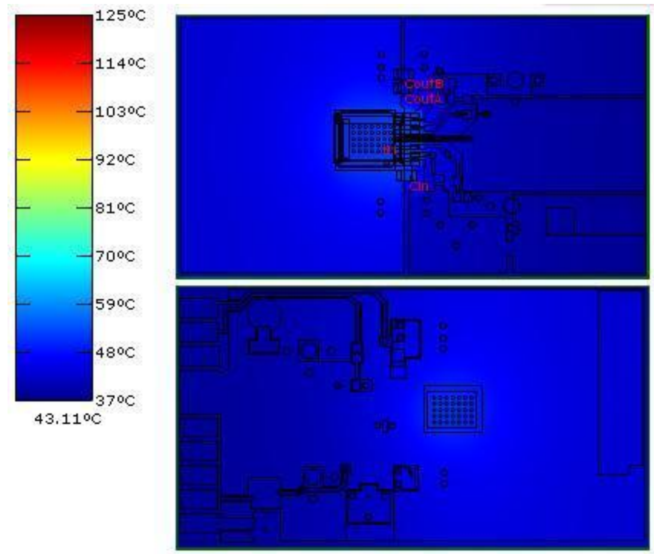
LMZ12003 Regulator Design



$$Vout = 0.8 * \left(1 + \frac{Rfbt}{Rfbb}\right) \quad ; \quad DESIGN:\ Vout = \ 0.8 * \left(1 + \frac{5.62}{1.07}\right) \ = 5.0019\ Volts$$

- Regulator for original design.
- Input 12V : Output ~5 V, as shown.
- Capable of up to 3A output load, which covers our entire system, if necessary.
- Automatic shutdown when 1.18 V is reached.

Efficiency and Thermal Considerations



- Over 90% efficient from 0.3 A to roughly 2.5A output.
- Likely no thermal issues at the regulator.
- If using new power source, another regulator with comparable or better specs has been found.

Physical Specs and Reqs

- The unit shall have a weight of no more than 50 lbs.
- No more than 10 lbs. can be attached to the user's head; the remaining weight shall be distributed elsewhere.
- Any electrical components attached to the helmet shall be covered for safety.
- Components in the system will be secured properly with screws and within the backpack to prevent problems during movement.

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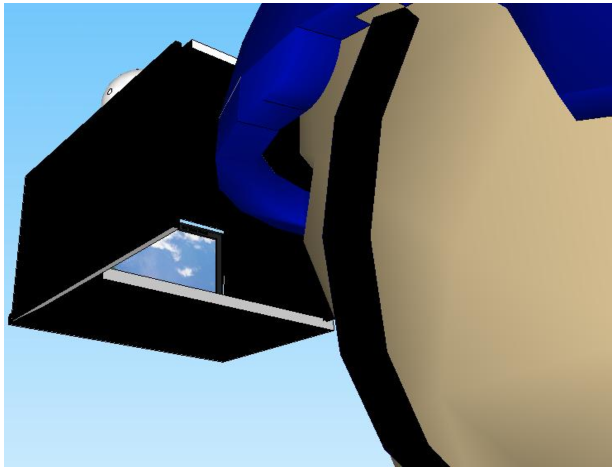
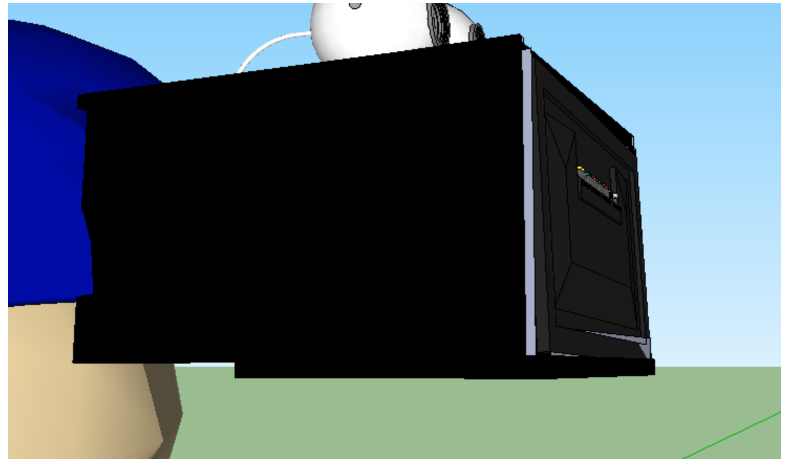
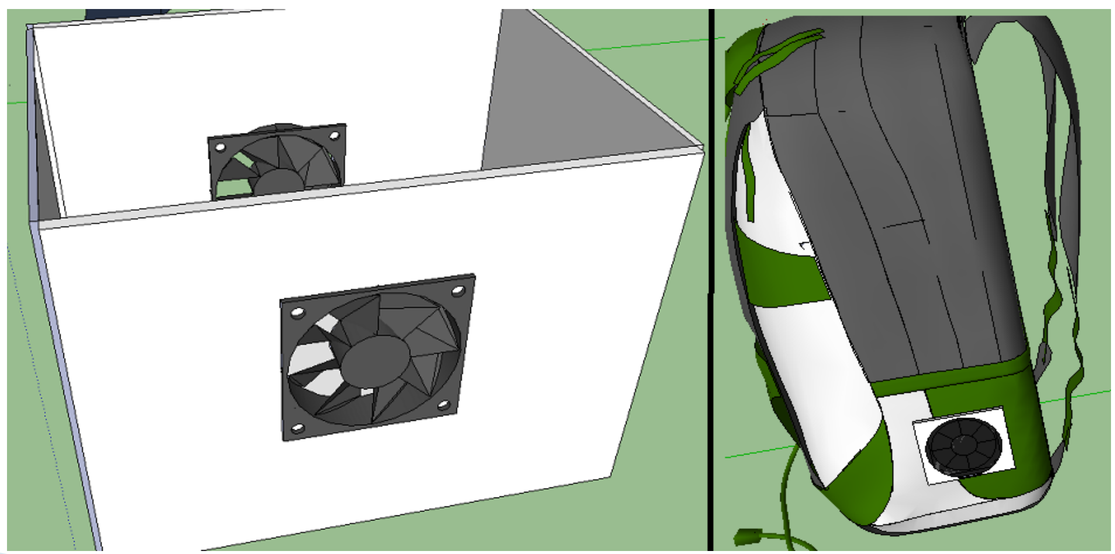
Physical Distribution Overview



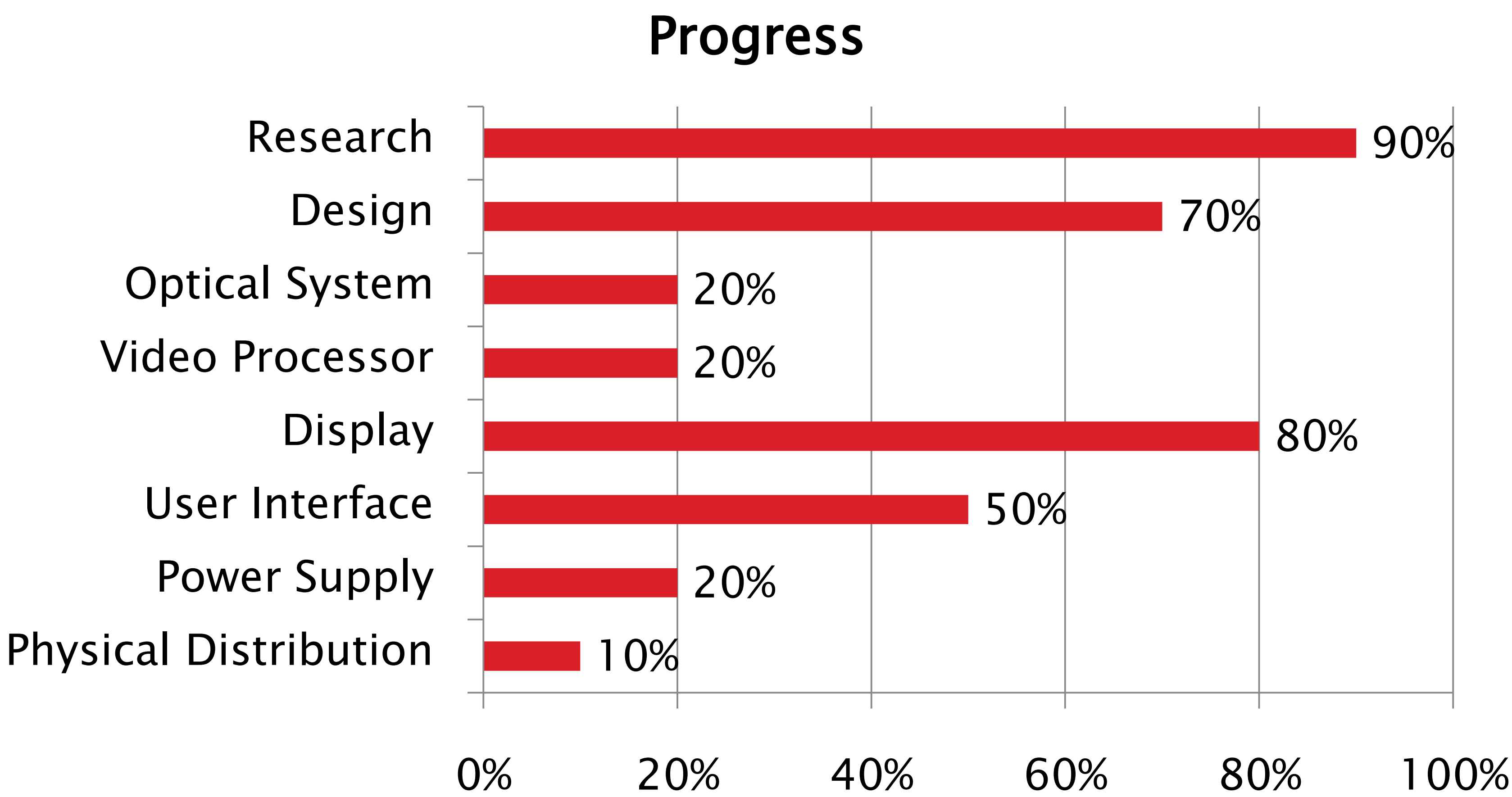




Current Project budget/ Estimated Final budget

- C3188A Camera – $56.95 x3 = $170.88
- UV and IR lenses – $60.00
- Nexsys2 FPGA – $100.00
- PSOne Display Screen – $60.00
- 12 V7 AH PS1270 Battery – $19.00
- Power Supply 5V Regulator – $5.00
- Arduino Duemilanove – $30.00
- Backpack and Bicycle Helmet – $40.00
- Testing supplies – $100.00
- Total: $584.88

Current project progress (as of CDR presentation)



Immediate plans for completion

- Resolve camera issue; configure new camera for digital output while testing filtering via composite output.
- Continue building FPGA code for video processor.
- Continue UI microcontroller programming and setup, order PCB.
- Reconfigure power supply design for new camera, if cost and time permit; otherwise, build as currently designed.

Questions?