AUTONOMOUS SURFACE VEHICLE

ASV 2008 – Son of a Boatname

<u>Group 1</u>
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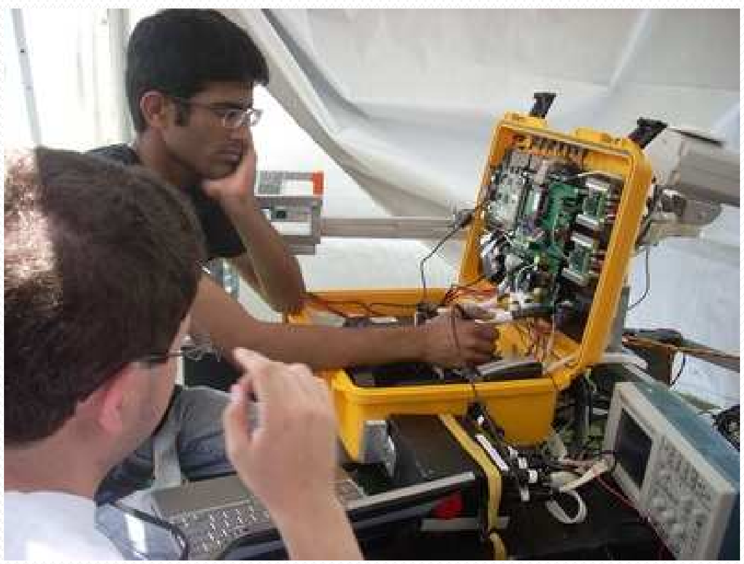
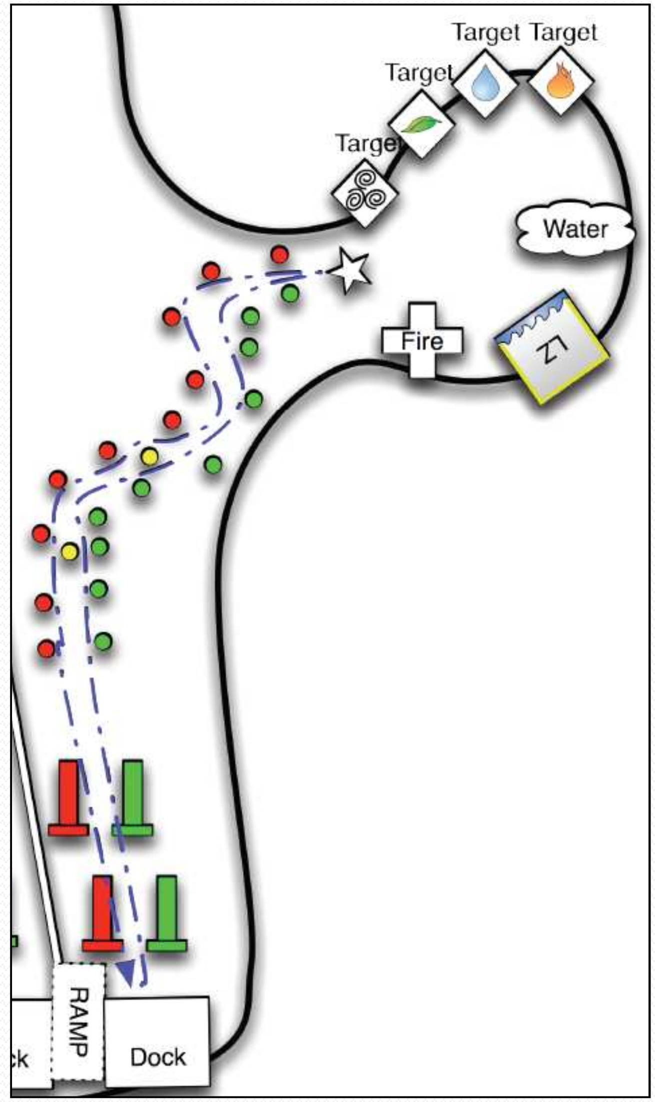
ASV 2009 – SS Boatname

ASV 2010 – Boatname the Brave

Autonomous Surface Vehicle

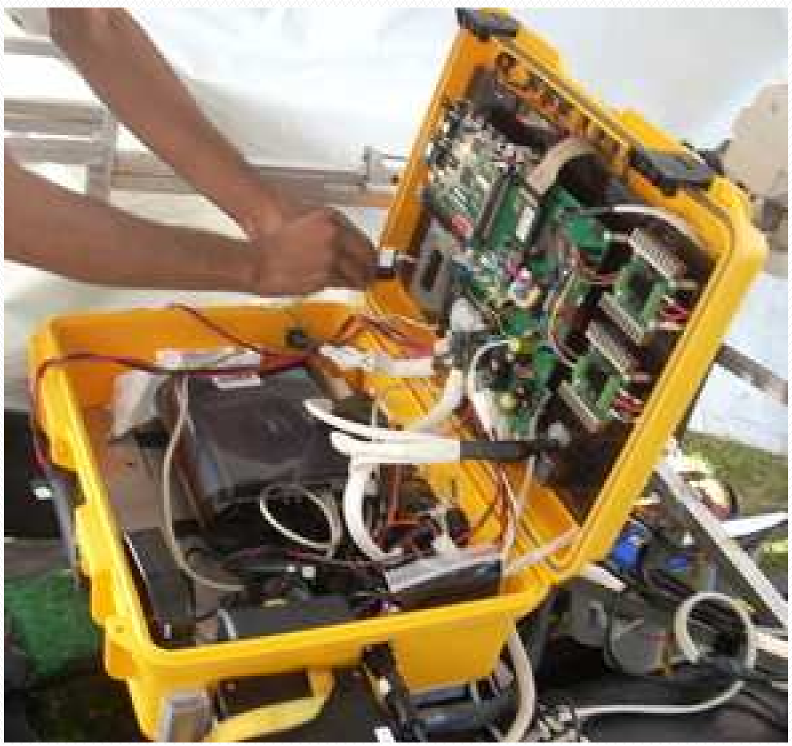
- Robotics Club at UCF
- AUVSI and ONR
- Virginia Beach, Virginia
- Strong History
- www.roboboats.org

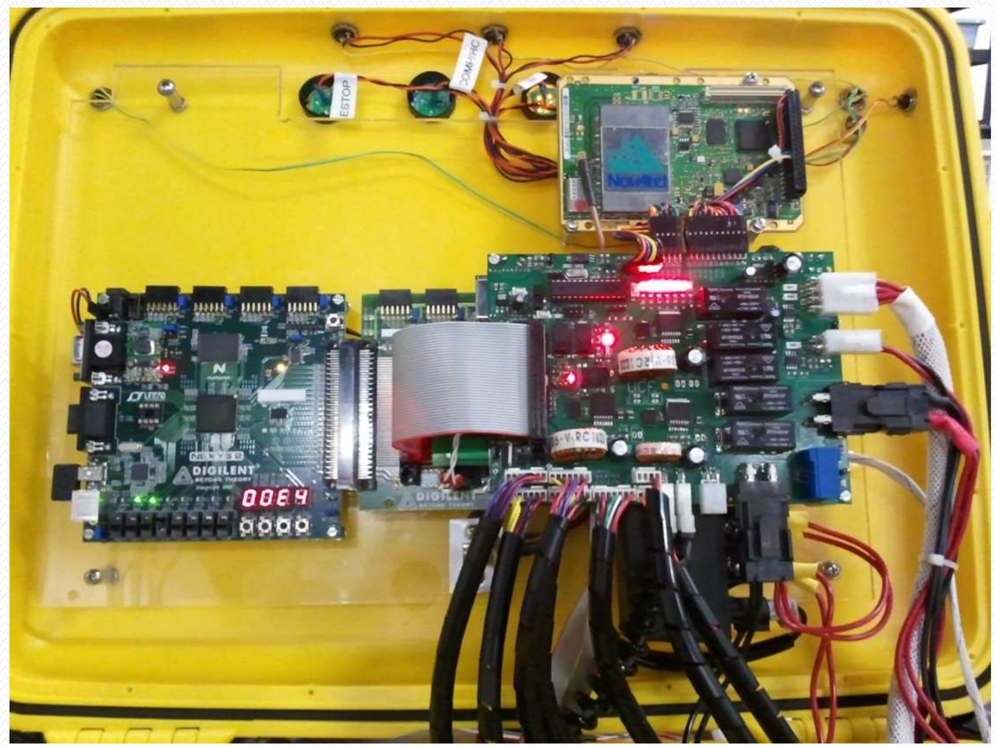




Objectives and Goals

- Improve on Last Year
- 24 V DC System
  - Efficient Power Distribution
  - Increased Run Time (2 hours)
- Monitor System Vitals
- Safe Vehicle
- Ergonomic Layout



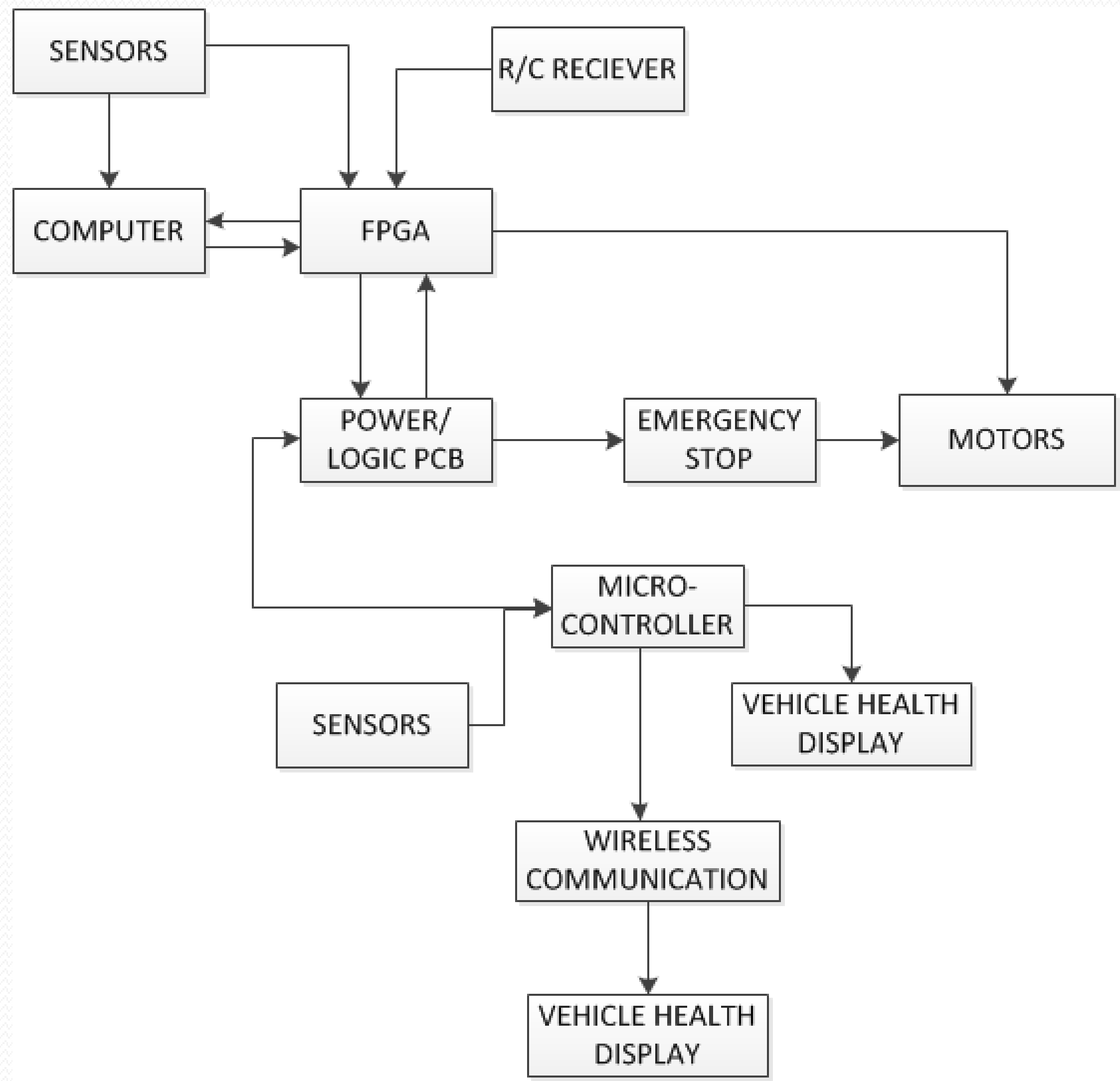


Specifications and Requirements

- Nominally operate using our 16 V DC and 24 V DC batteries
- ≥85% Efficiency
- Monitor input voltage and current with ±1.0% accuracy
- Monitor temperature and humidity with ±3.0% accuracy
- Seamlessly switch from shore power to battery power
- Meet all rules and regulations set forth by AUVSI

Project Block Diagram

- Power/Logic PCB
  - Integrates most power and signals
- Microcontroller
  - Simple sensors & feedback
- FPGA
  - Communication with computer and input/output signals



Power– Batteries / Shore Power

- Available Batteries
  - 4 Cell – 16 V DC Nominal
  - 6 Cell – 24 V DC Nominal
    - More efficient – 33% Savings
- Shore Power
  - Rhino Power Supply
    - 24 V DC @ 25 A
- Needs to operate using any battery combination

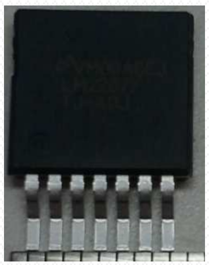
Power – Linear vs. Switching

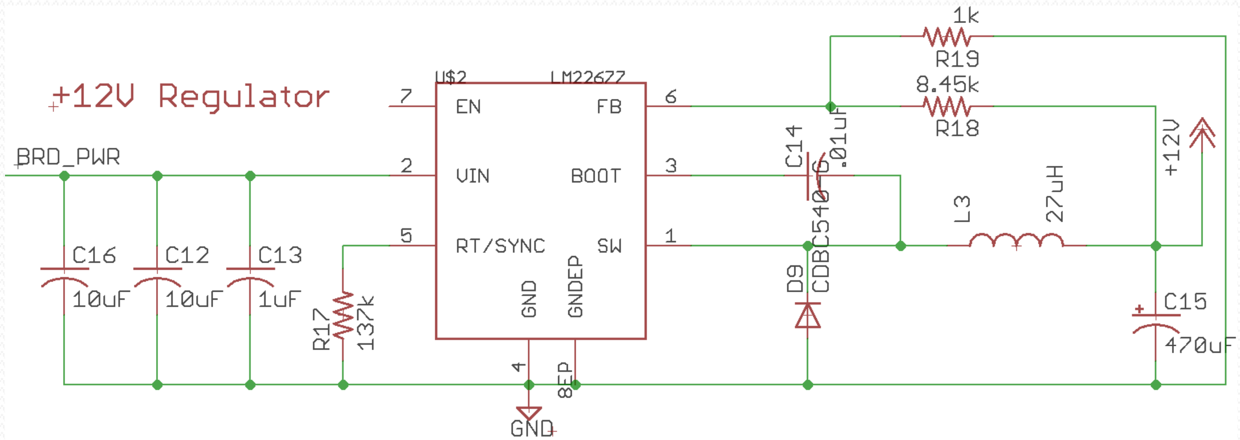
- Linear
  - High Efficiency when $V_{IN} - V_{OUT}$ is small
  - Low Noise
  - Dissipates Heat
- Switching
  - High Efficiency
  - Low Heat Dissipation
  - More Complex
  - Switching Ripple

Regulator	Input (V)	Output (V)	Output (I)	Type
1	24	12	4.0	Switching
2	24	12	1.5	Switching
3	24	8	1.5	Switching
4	24	5	3.0	Switching
5	5	3.3	0.8	Linear

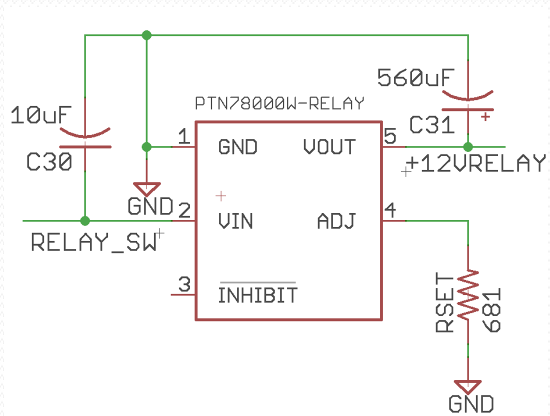
Power – Regulator Schematics

12V @ 4 A

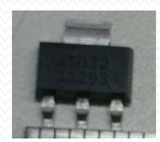


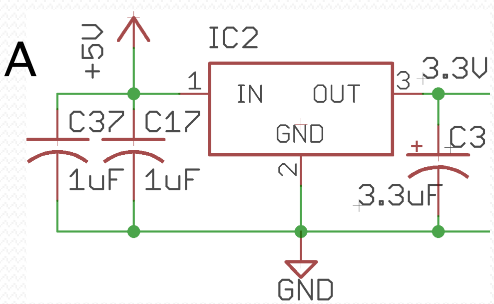


12V @ 1.5 A



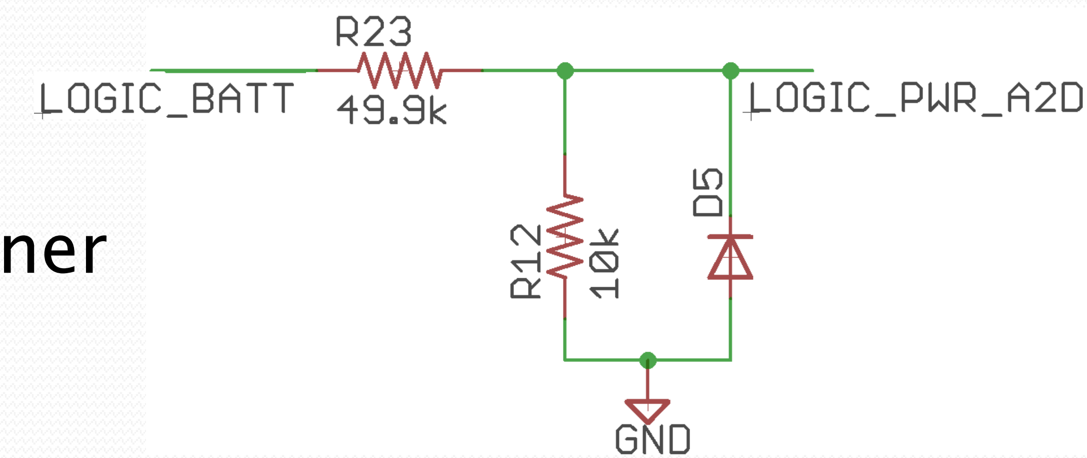
3.3V @ 0.8 A





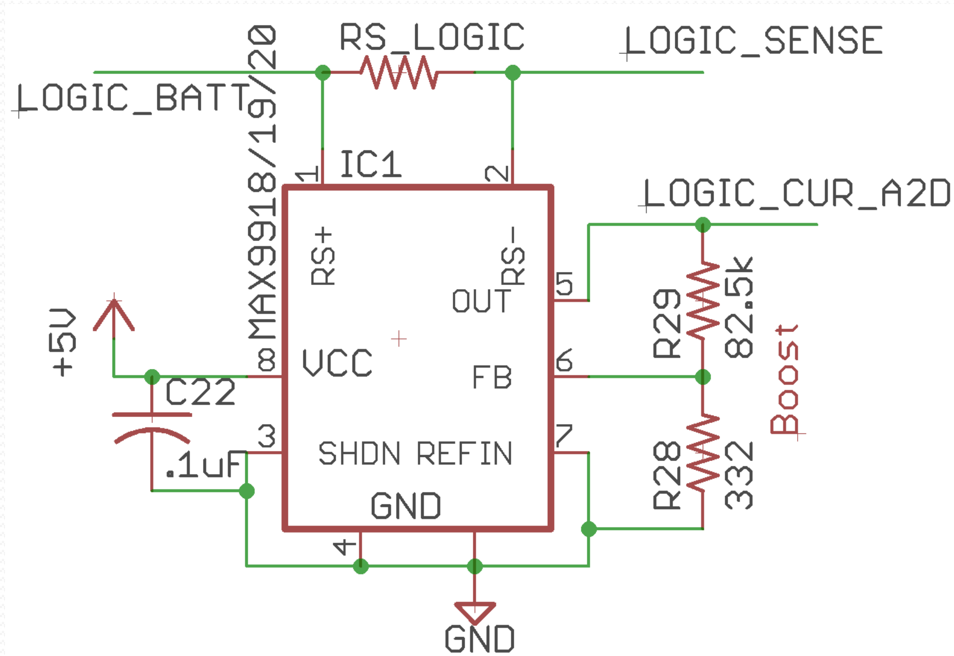
Sensing – Voltage

- Measurement taken directly from input source
- Scaled by 1/6
- Initially had 4.7V Zener Diode
- Measures:
  - Logic Batteries
  - Motor Batteries
  - Shore Power



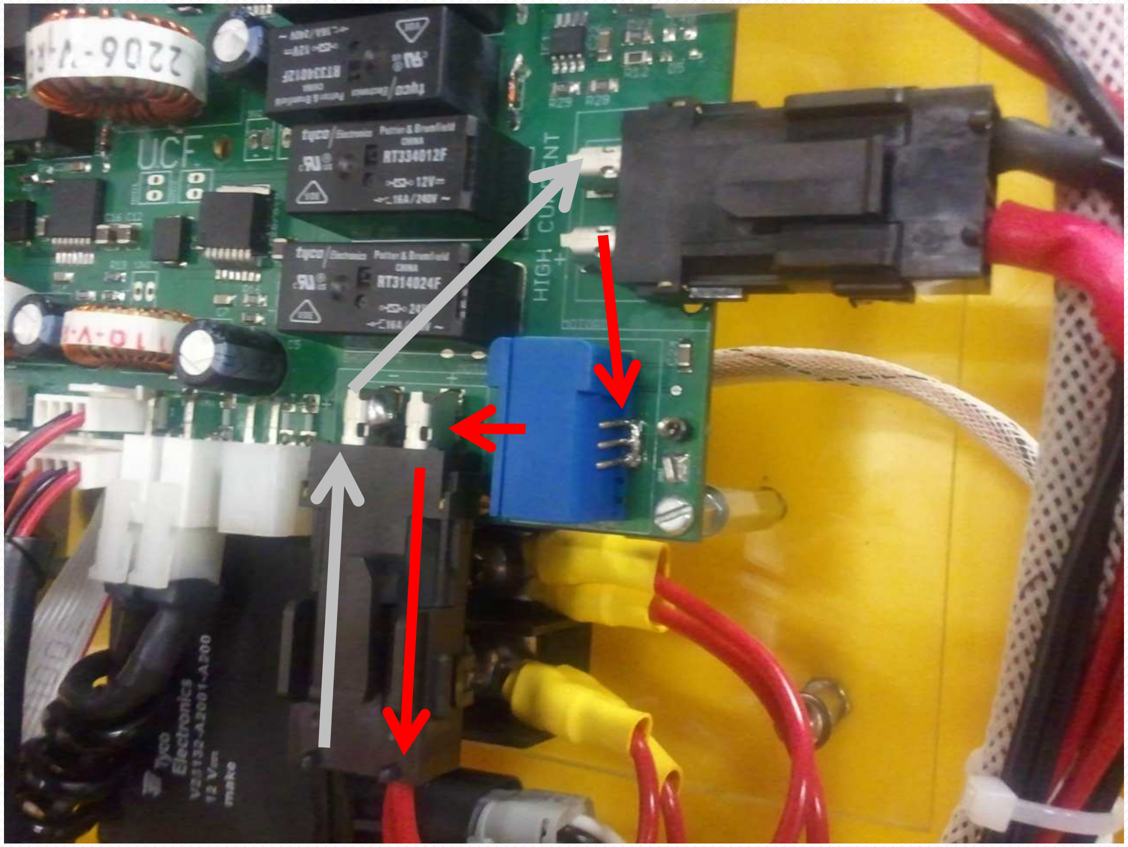
Sensing – Current – Shunt Resistor

- Accurate
- Low Cost
- Insertion Losses
- Sense Resistor
  - 5mΩ for Logic
  - 2.5mΩ for Shore
- Logic – $15A_{MAX}$
- Shore – $30A_{MAX}$



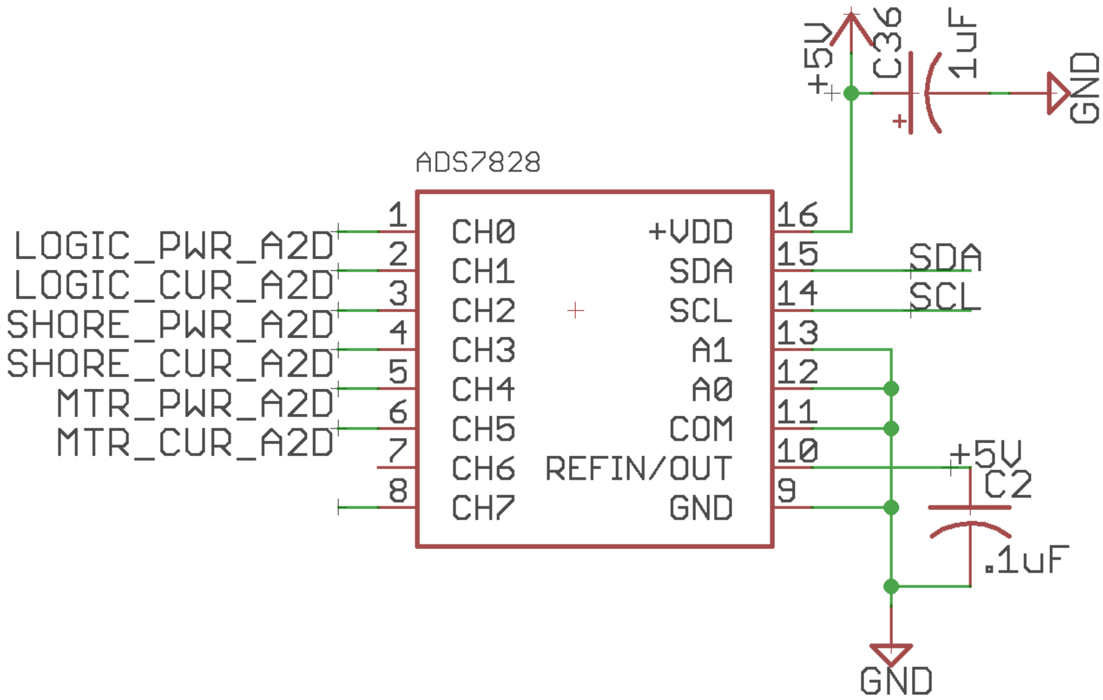
Sensing – Current – Hall Effect

- Motor Power
- Higher Current
  - $15A_{NOM}$
  - $51A_{MAX}$
- Higher Cost
- No Insertion Losses
- Exposed Leads
- Voltage Output
  - Added Filtering

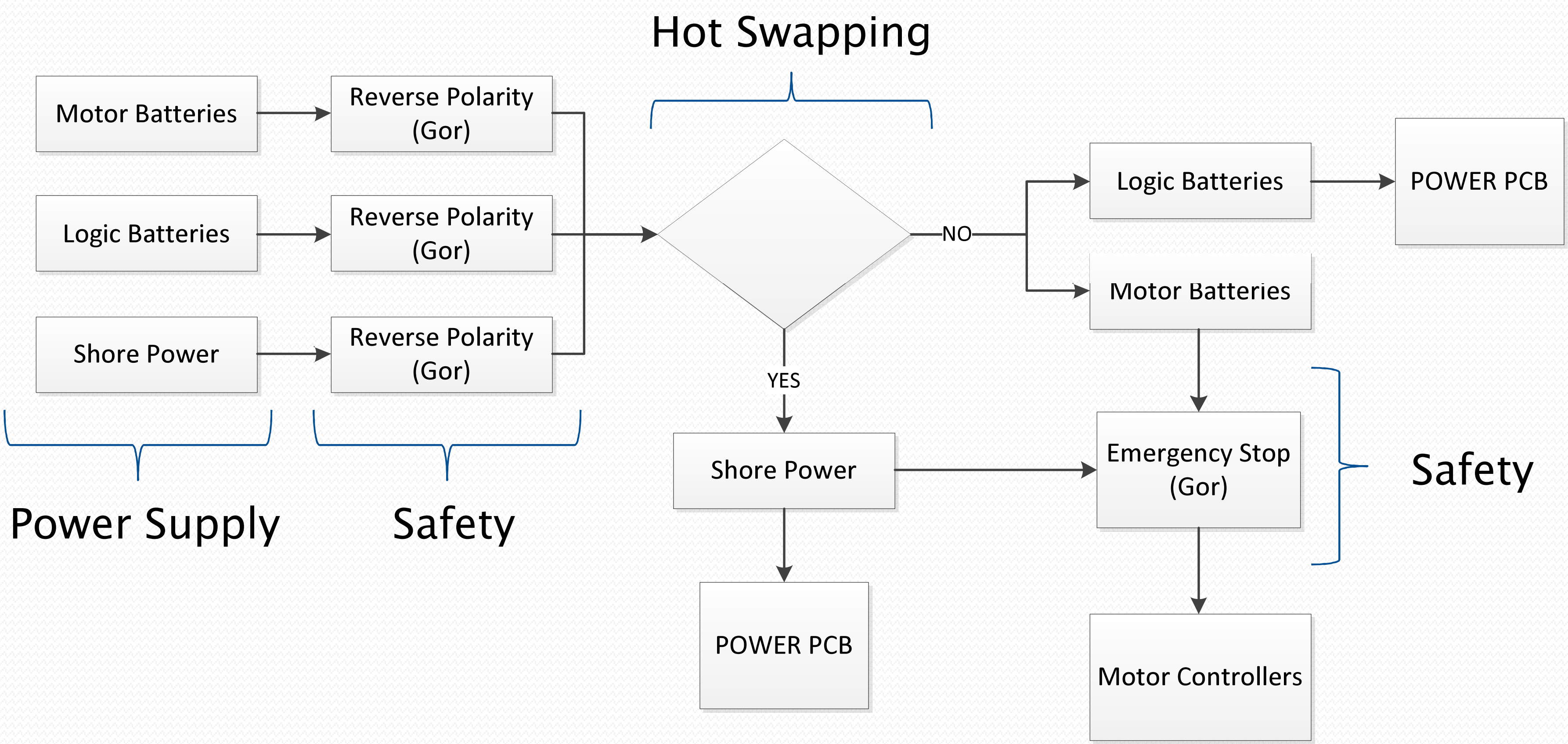


Sensing – Analog to Digital

- 12-Bit A2D
- I^2C Interface
- Close Proximity to Sensors



Power Flowchart



Reverse Polarity

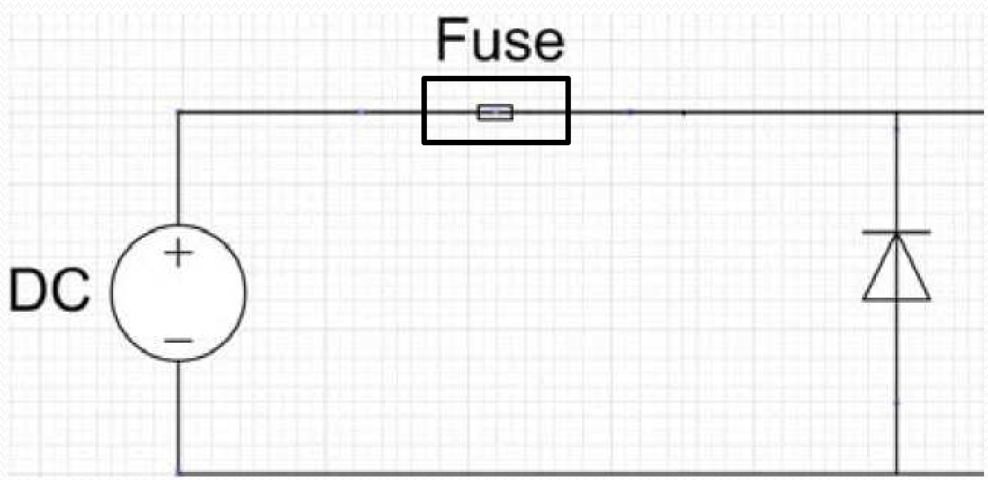
Reverse Polarity Goals

- Minimum power dissipation
- Implement for all power sources

Source	Maximum Current
Logic Battery	15 A
Shore Power	30 A
Motor Battery	30 A

Fuse-Diode Implementation

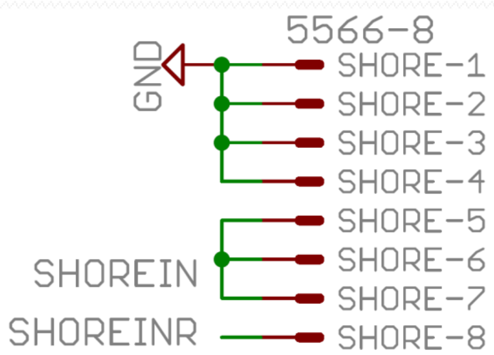
- Negligible drop across diode
- Negligible total loss
- Guaranteed to work by design

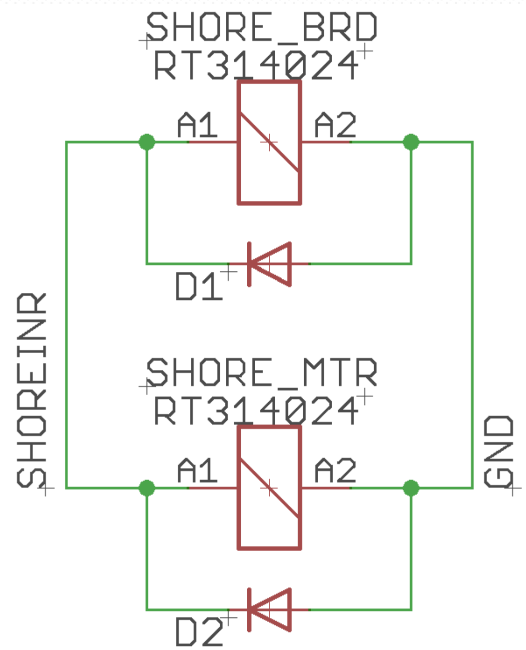


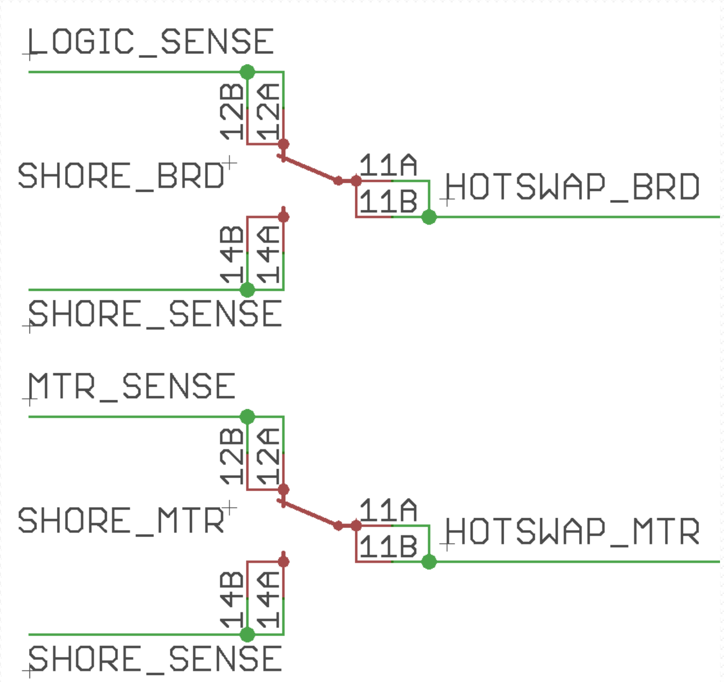
Hot Swapping

Relay Implementation

- Practically lossless
- Very reliable
- No logic components



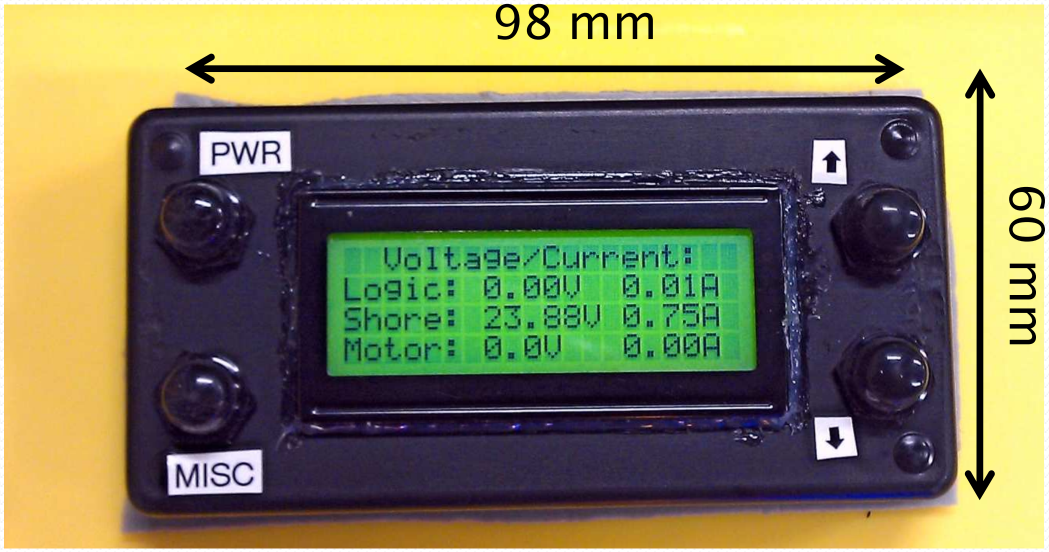




Display

<u>**Our Requirements:**</u>

- Technology: LCD
- Display type: Alphanumeric
- Backlight: LED
- Character Specs: 20 x 4
- Interface: RS-232 or I^2C



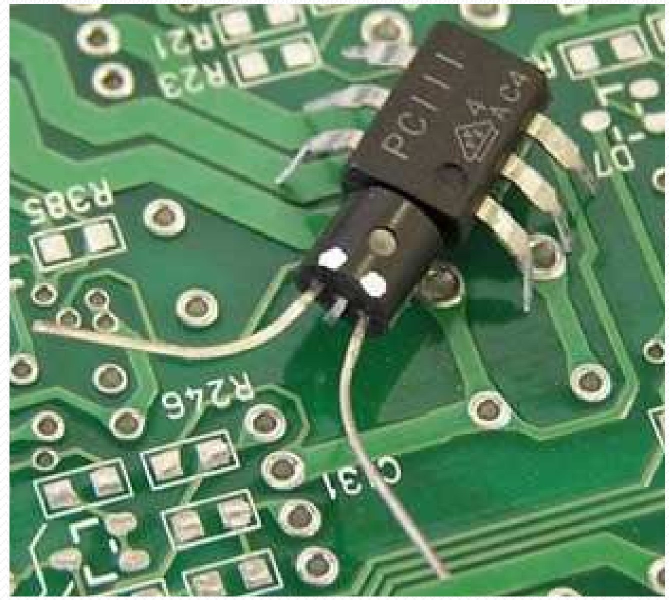
<u>**Implementation:**</u>

- Use waterproof buttons for control
- Resistor divider with 4 buttons to single I/O pin
- Serial Communication

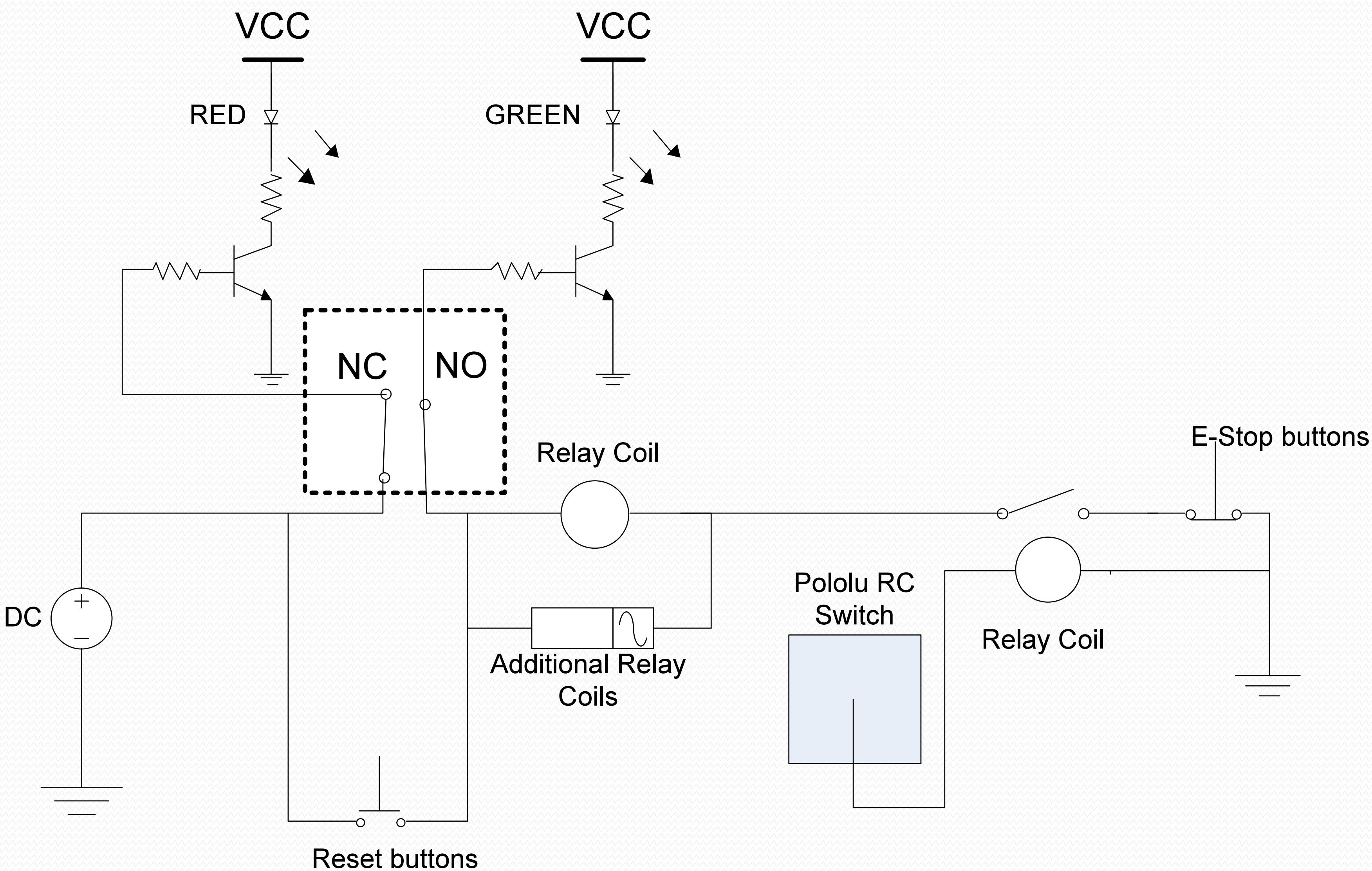
E-Stop Requirements

- Use minimum logic devices
- Must disengage all moving parts
- 1 reset button
- 5 E-Stop buttons (2 remote)
- < 5 W power dissipation
- E-Stop state indicators
- Digital output for Microcontroller

This year we have avoided BUGS on the circuit

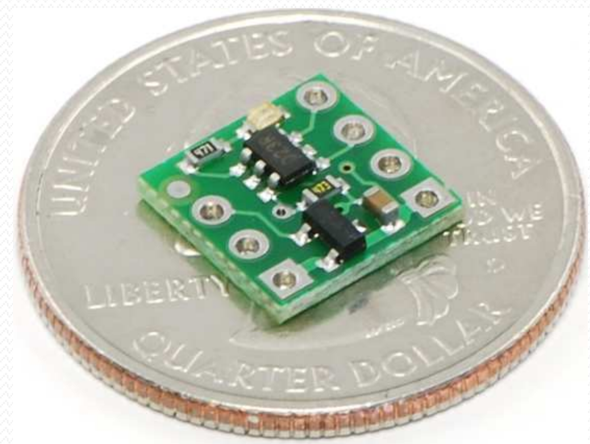


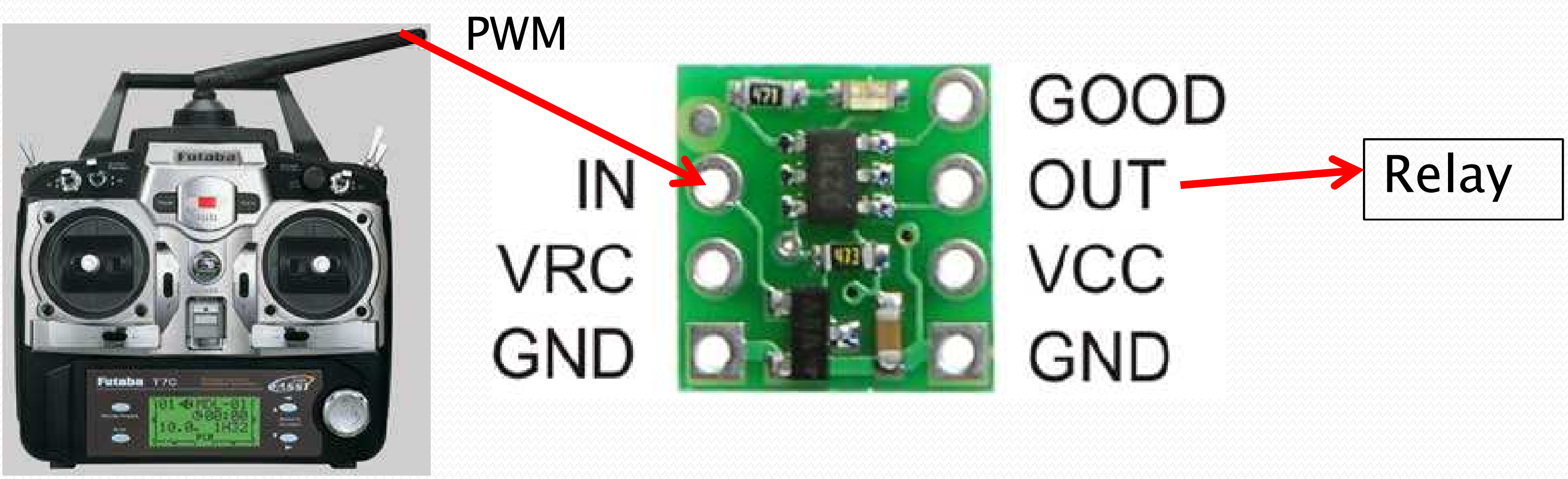
E-Stop Design



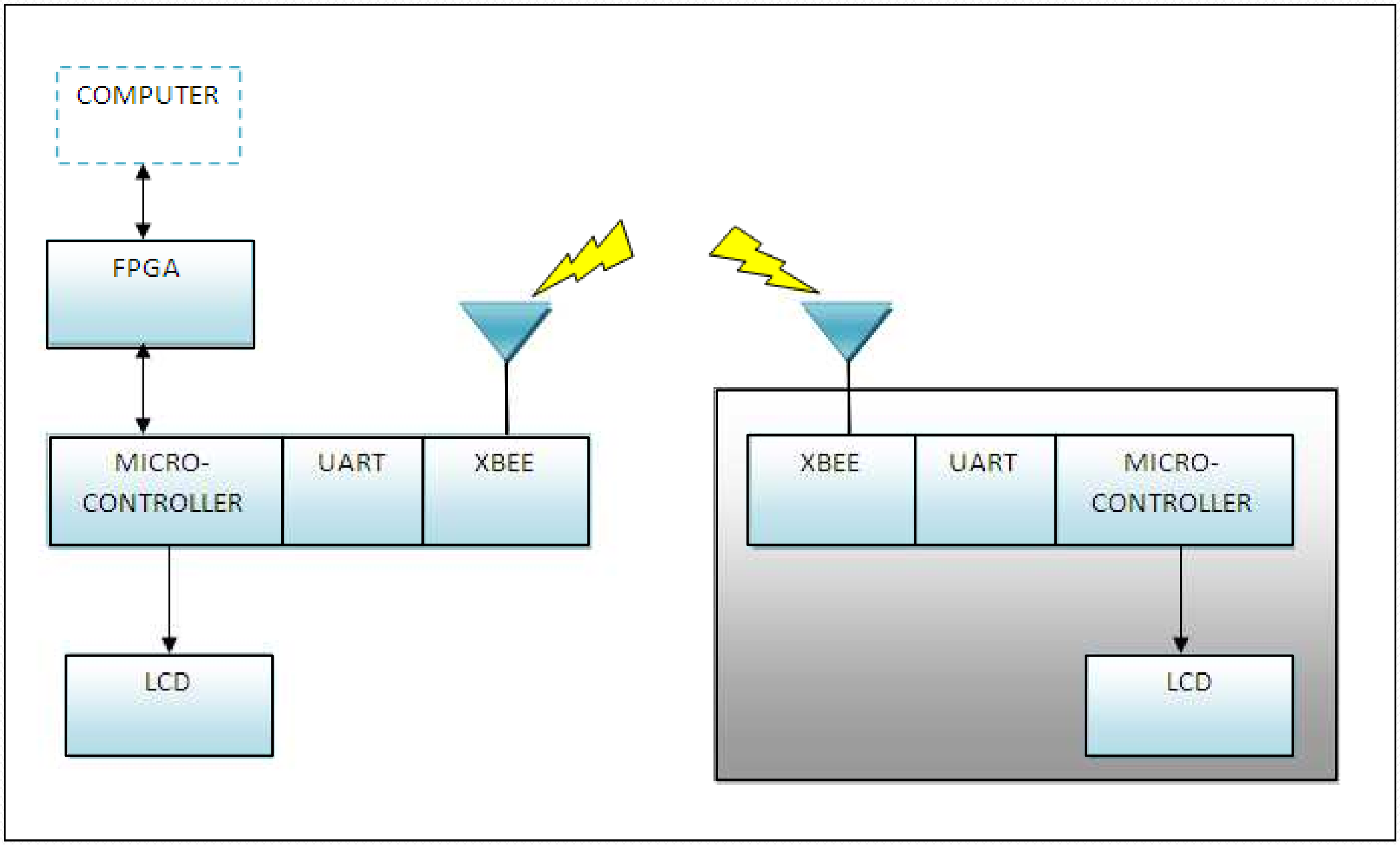
Pololu RC Switch

- RC Switch for Remote E-Stop
  - 5 V Input
  - Output controls relay coil



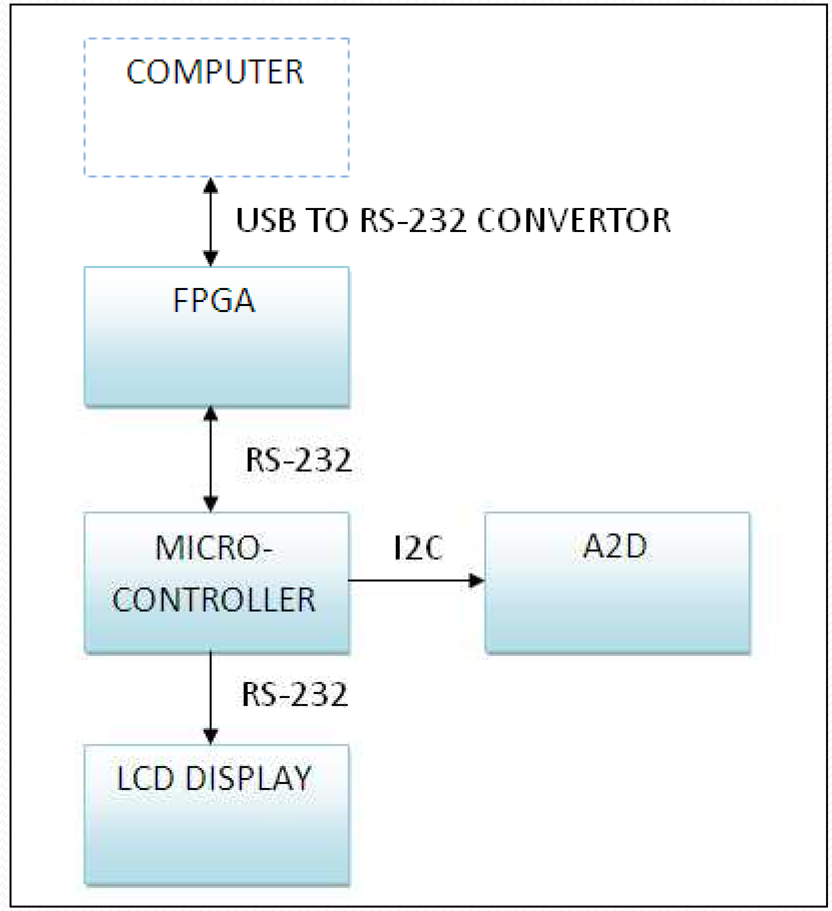


Wired/ Wireless Communication Platform



Wired Communication

- Microcontroller has one designated I2C port
- A2D convertors utilize I2C
- RS-232 for communicating microcontroller to the LCD displays and to the FPGA.



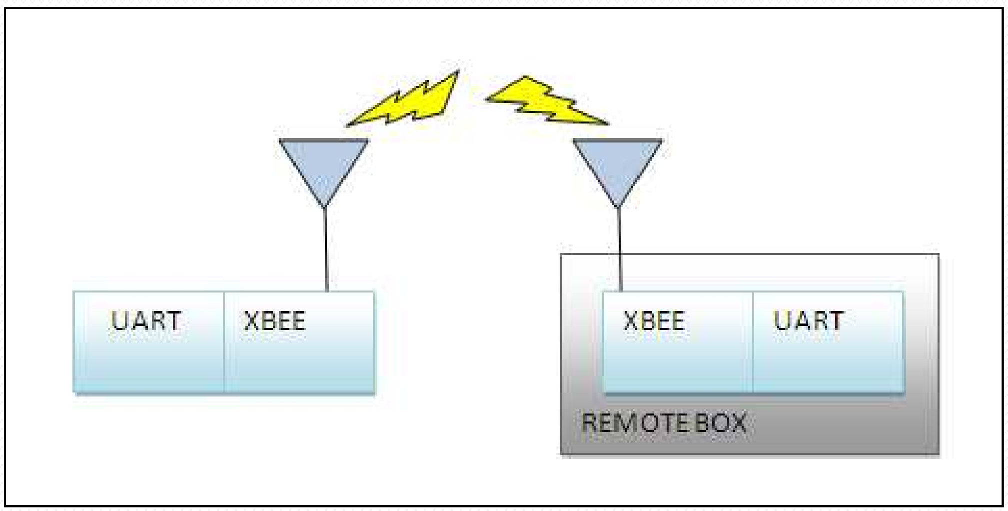
Wireless Communications

Our Requirements

- Minimum 900 ft "open-line-of-sight"
- Point-to-multipoint communication
- Low power consumption

Error Checking Protocol

- Packet uses 8 byte structure
- 2 Start bytes ("#" and "%")
- 1 Byte for command
- 4 Bytes for data
- 1 Byte for checksum



Sensors

- We have implemented various sensors on the ASV
- Sensors implemented into our design include:
  - Temperature sensors
    - System feedback
  - Humidity sensor
    - System feedback
  - Light sensors
    - Challenges

Temperature Sensor

Specifications

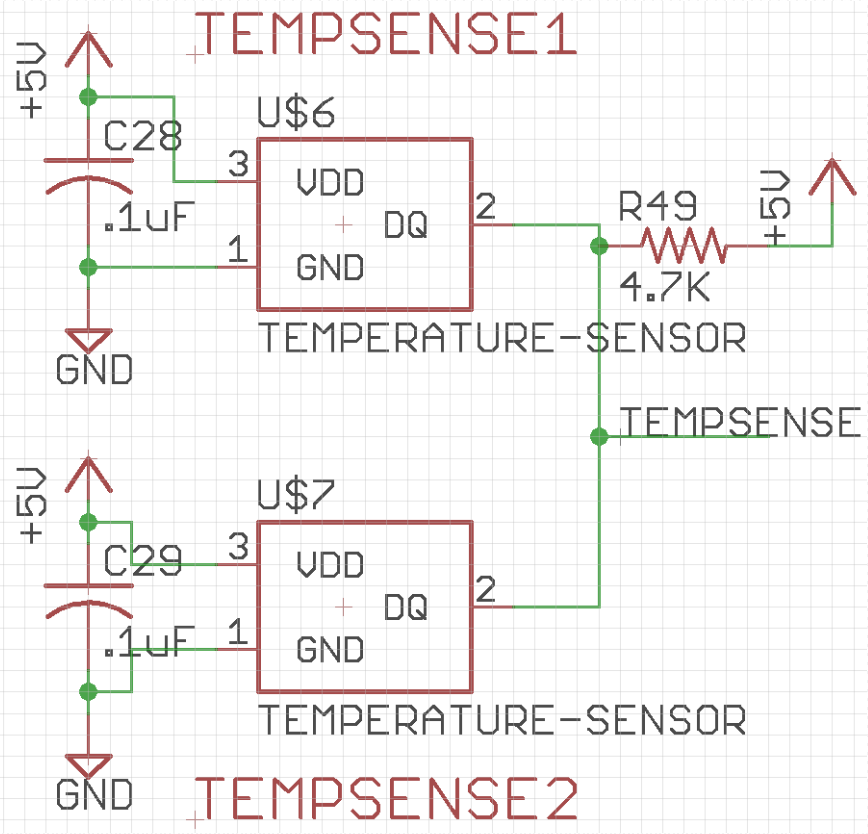
- Operating in a range from – 55°C to +125°C
- Power supply range of 3.0 V to 5.5 V
- Resolution of 0.5°C
- Temperature accuracy of ±0.5°C @ 25°C

Advantages

- 1-wire communication
- Multiple devices on a bus

Schematic

Maxim's DS18S20



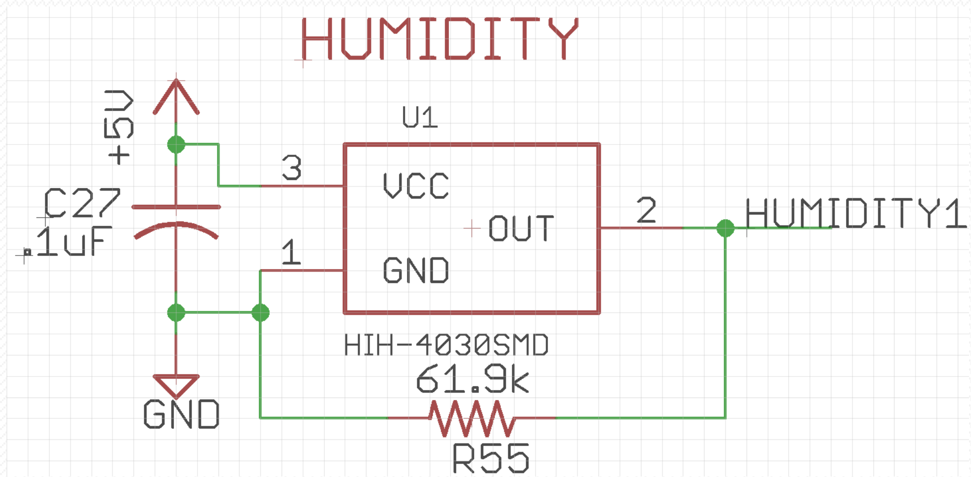
Humidity Sensor

Our Requirements

- Read humidity values in the range of 10% to 90%
- Works with our 5 V power supply.
- Provide an accuracy of ±3.0% Relative Humidity

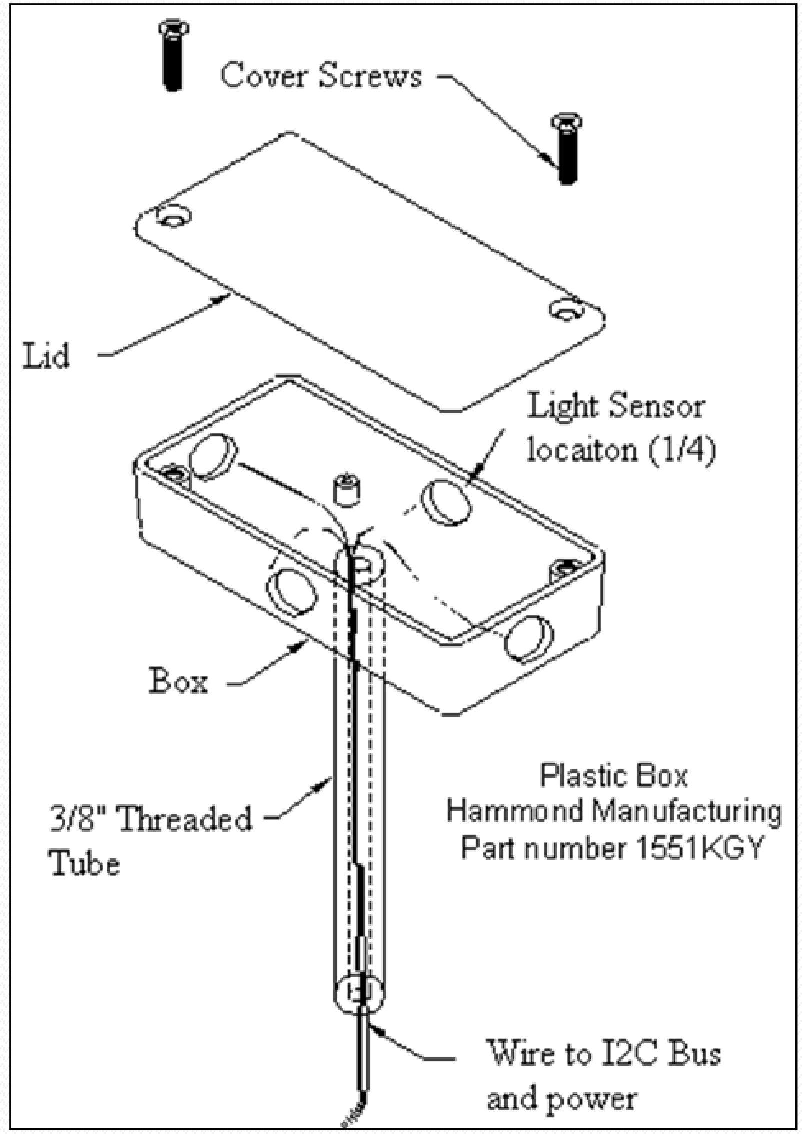
Schematic

Honeywell HIH-5030

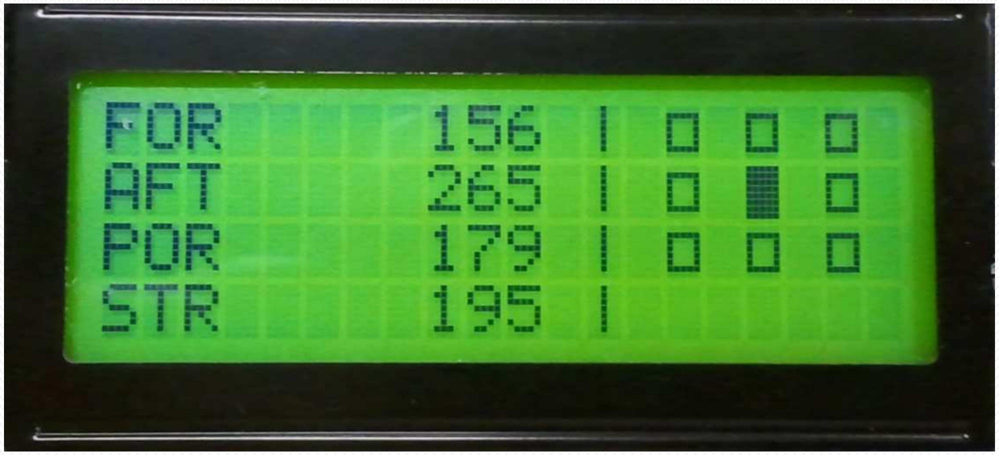


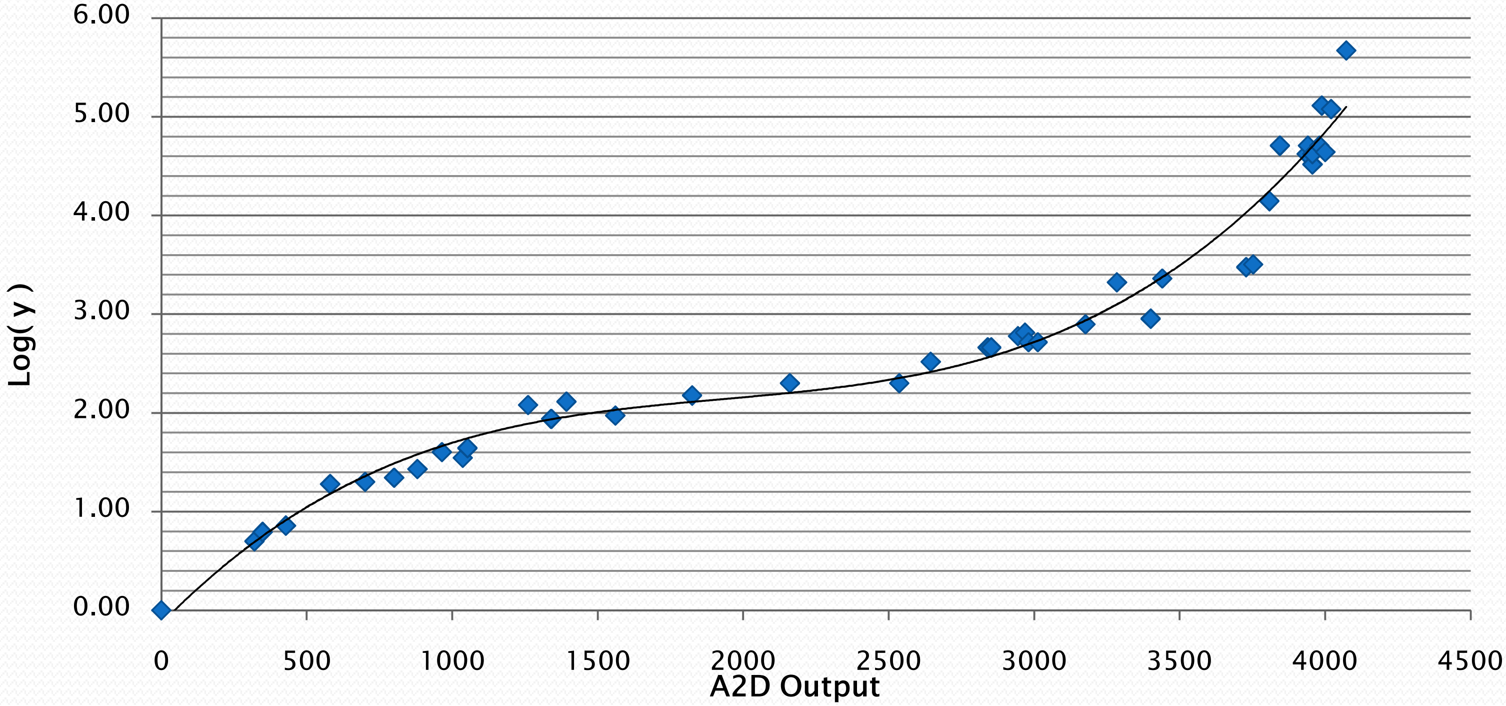
Light Sensor

- Simplistic voltage divider design
- (4) Photo-resistors encased within a black box
- Used CAT5e cable for connection to A2D
- Capable of reading 0 to 100,000 Lux



Light Sensor Data Curve





FPGA vs. Microcontroller

We chose to use both…

FPGA Advantages:

- Processing is done in parallel for near real-time realization
- Extremely flexible in logic based implementation
- Clock rates can be lower and achieve similar results as a μC

μC Advantages:

- Cost efficient
- Power Consumption is less
- Communication between devices is much easier

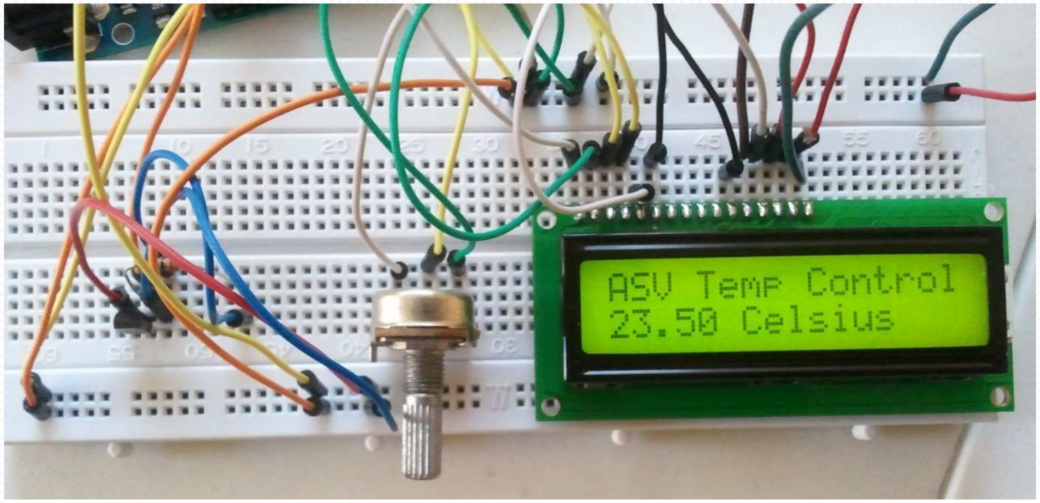
Programming Environment

- Microcontroller
  - AVR Programmer (ICSP)
  - C language
  - Windows/Linux

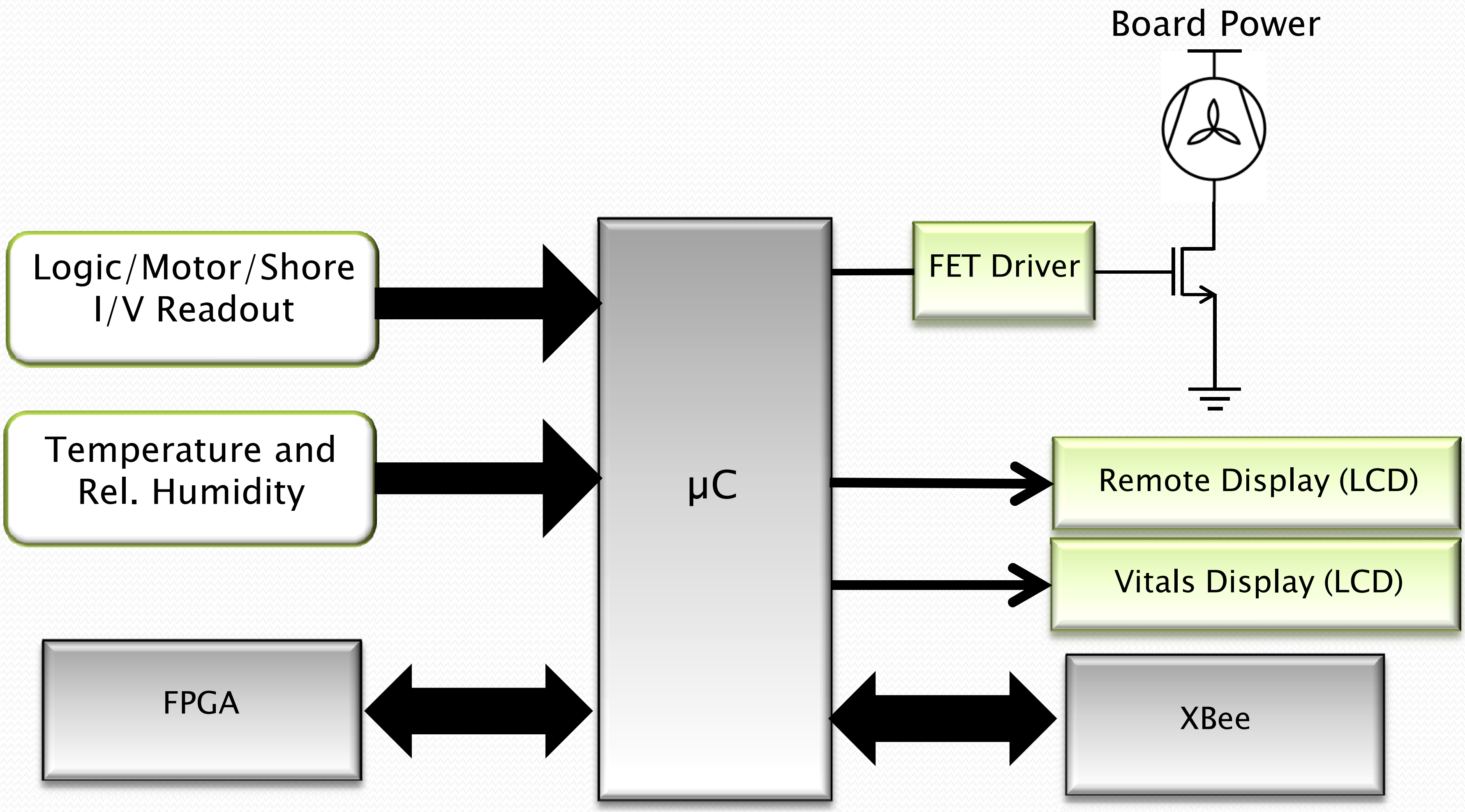
- FPGA
  - Xilinx ISE WebPack
  - JTAG Interface
  - VHDL language
  - Windows/Linux

Microcontroller – Atmega328p

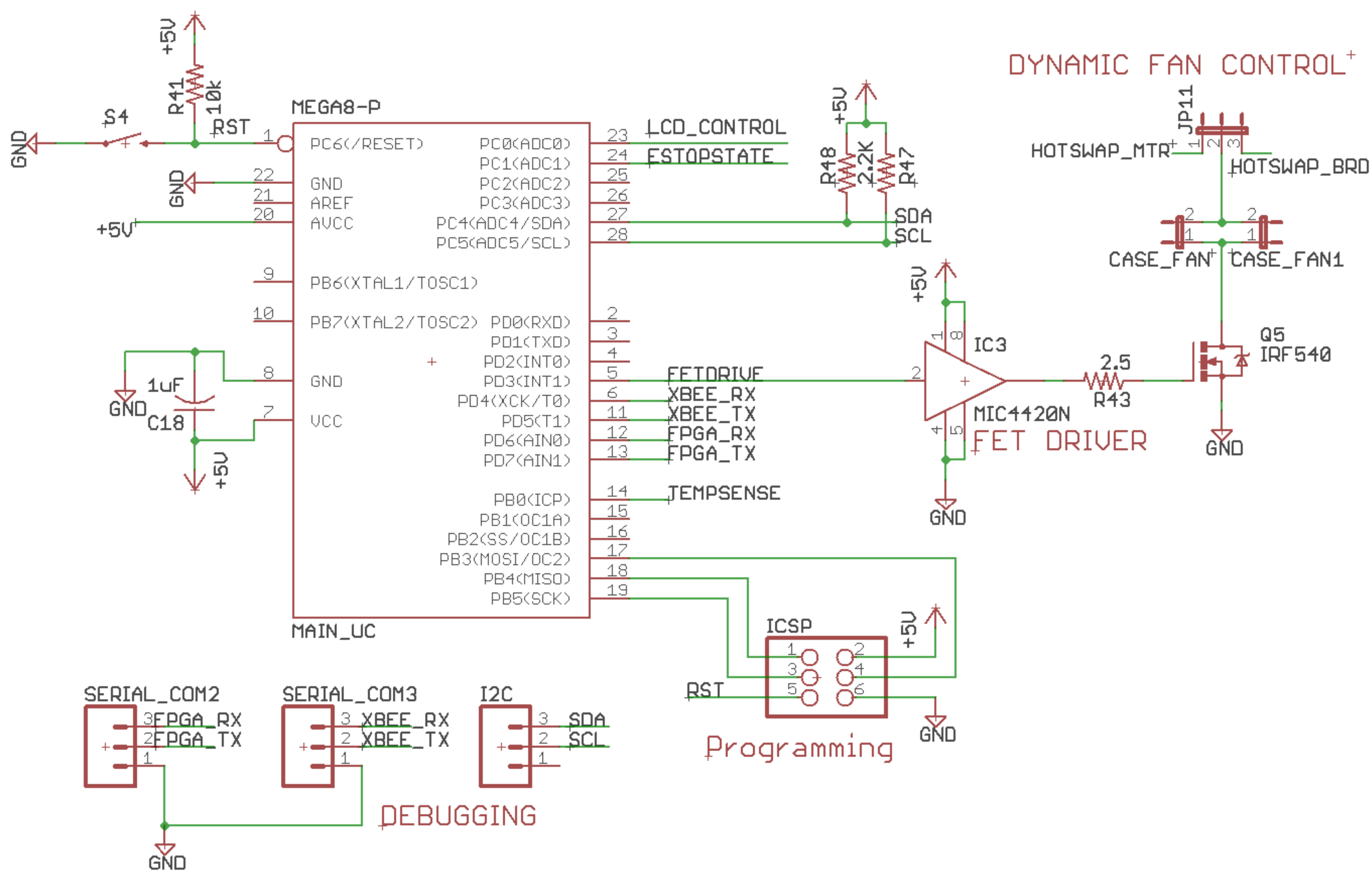
- Analog to digital conversion (Dedicated ADC as well)
- Display vitals on an LCD screen
- Regulate air flow through case based on ambient temperature in the case.
- Transmit data wirelessly to remote box by interfacing with a XBee



Logic Overview

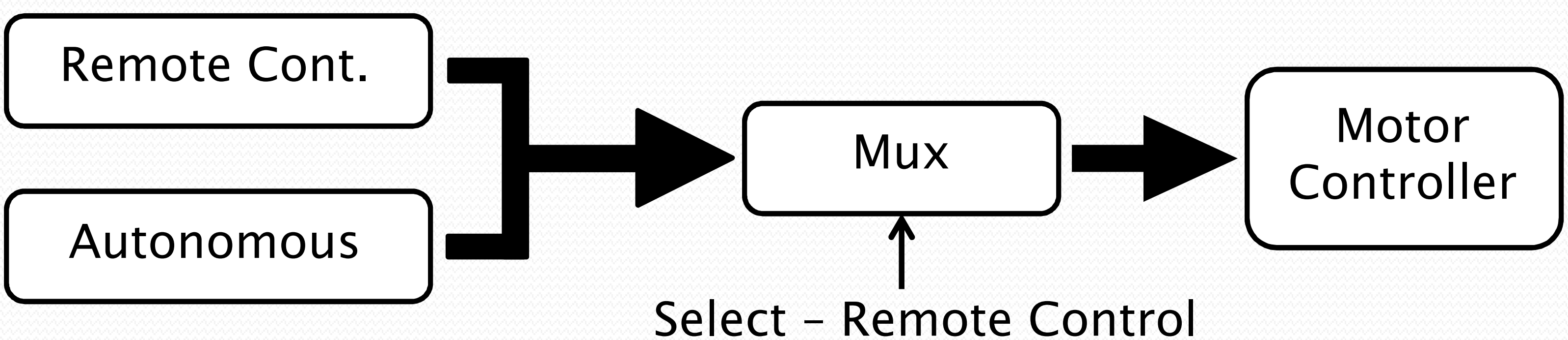


Microcontroller – Schematics



FPGA – Xilinx Spartan 3E

- Communicate vehicle vitals to the on-board computer
- Control indicator LEDs on the vehicle
- Receiving the RC PWM signals from a remote controller
- Receiving thrust percentage values from on-board computer
- Mux the two signals mentioned above to be able to switch between autonomous and human controlled mode



Timeline

Item	Due Date	Progress
Research	12/04/2010	
Schematic/Design	01/25/2011	
Board Layout	01/30/2011	
Board Population	02/19/2011	
Board Testing	02/26/2011	
Integration	03/05/2011	

Budget

Future Costs:

- Travel – $2,000
- Sensors – $400
- PCB – $100
- Course – $400

Sponsors:

- IST
- Northrop Grumman
- SGA

ITEM	FINANCE	APPROXIMATE COST
GPS	ASV Team	$1,500
Compass	ASV Team	$1,500
Course	ASV Team	$1000
Batteries	ASV Team	$1,000
Camera	ASV Team	$700
FPGA	ASV Team	$150
Unibrain	ASV Team	$100
Subtotal (Already Purchased)		**$5,950**
LIDAR	Sponsorship	$3,950
ASV Computer	Sponsorship	$1,000
Crust Crawler Motors	ASV Team	$2,000
Motor Controllers	ASV Team	$850
PCB Components	ASV Team	$500
Mechanical	ASV Team	$500
ZigBee Pro 900Mhz	ASV Team	$150
HD Webcam	ASV Team	$100
Pelican Case	ASV Team	$100
Connectors	ASV Team	$100
LCD Screens	ASV Team	$60
Microcontroller	ASV Team	$20
Subtotal (New Costs)		**$9,330**
Total Cost		**$15,280**