AUTONOMOUS SURFACE VEHICLE

ASV 2008 – Son of a Boatname

Group 1
Michael Podel
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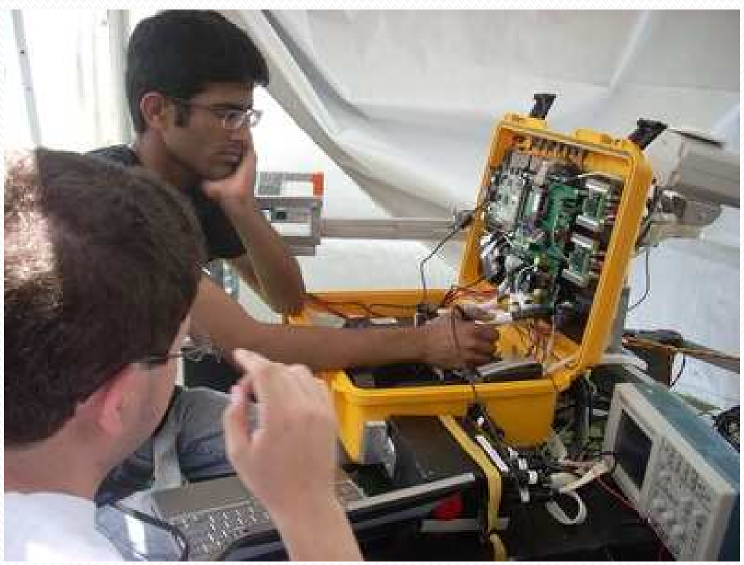
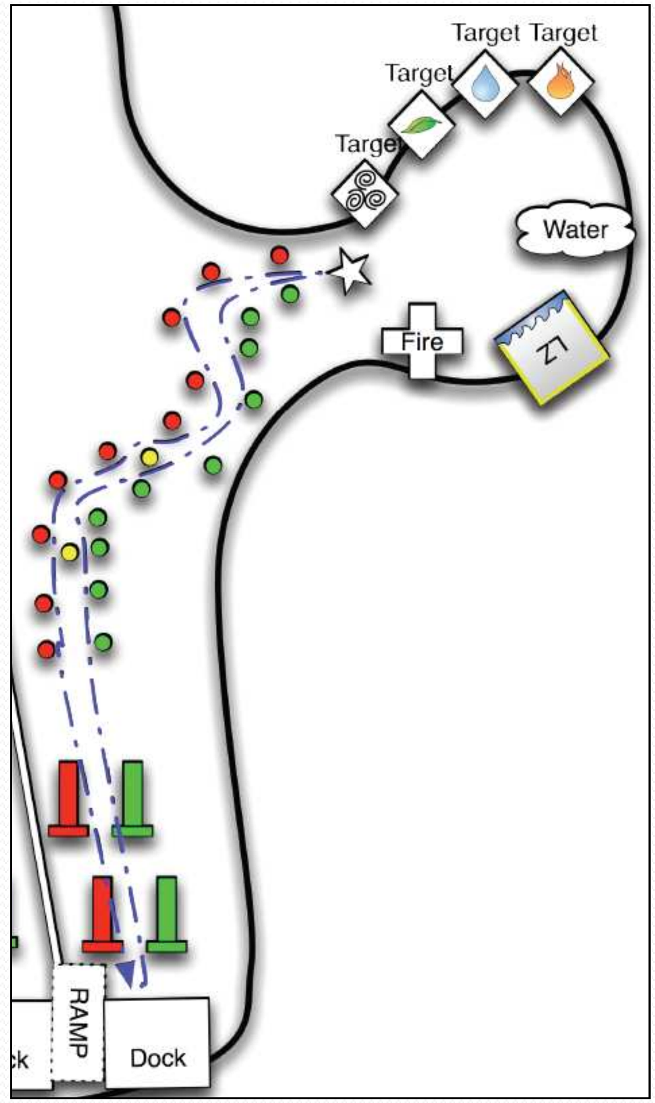
ASV 2009 – SS Boatname

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

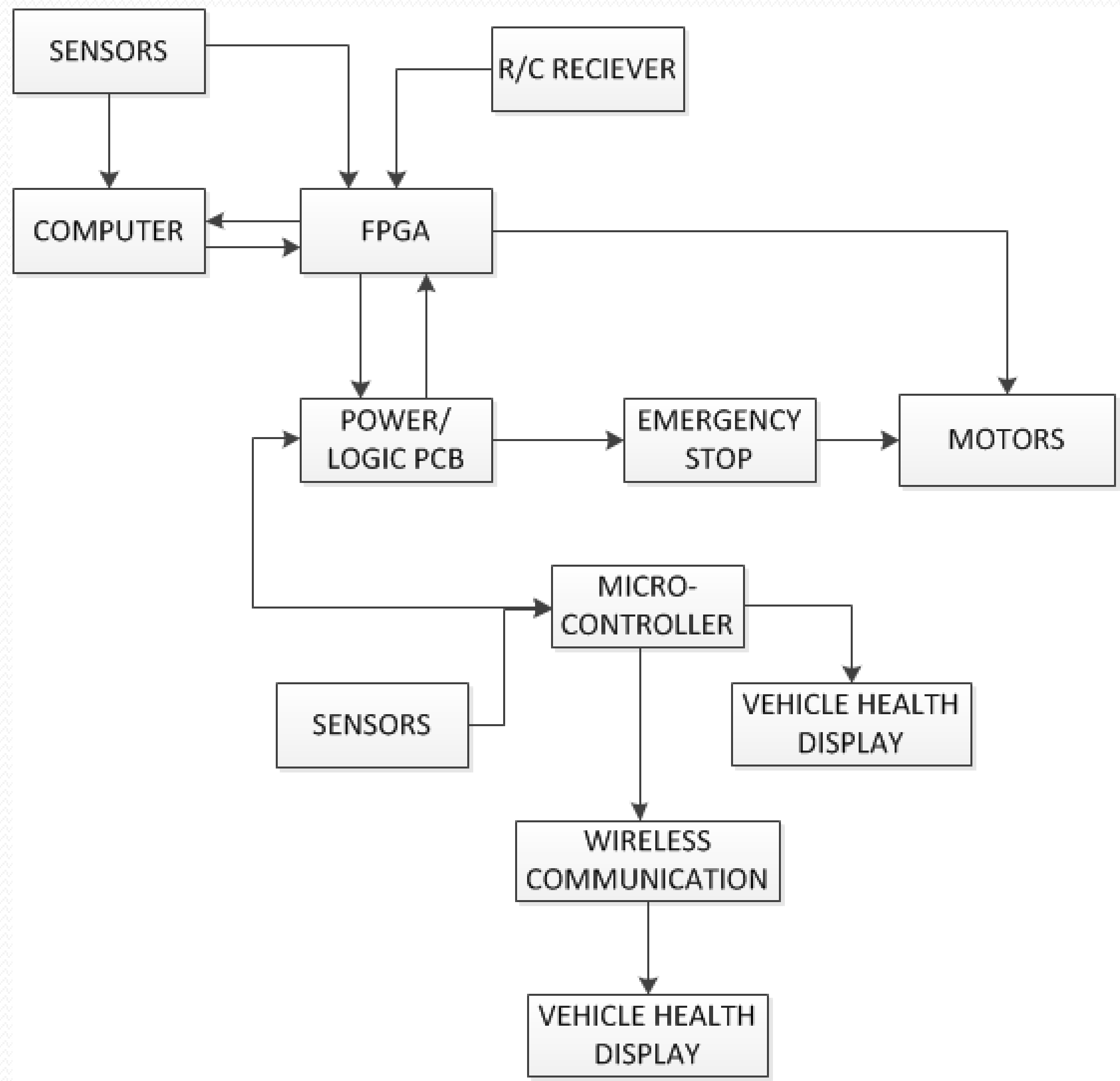
- Improve on Last Year
- 25 V DC System
  - Efficient Power Distribution
  - Increase Run Time (2 hours)
- Monitor System Vitals
- Safe Vehicle
- Ergonomic Layout

Specifications and Requirements

- Nominally operate using our 16 V DC and 25 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



Budget

Future Costs:

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

Sponsors:

- IST
- Northrop Grumman
- SGA

ITEM	FINANCE	APPROXIMATE COST
Stereo Vision	Lockheed Martin	$3,000
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)		**$8,950**
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		**$18,280**

POWER – Batteries / Shore Power

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

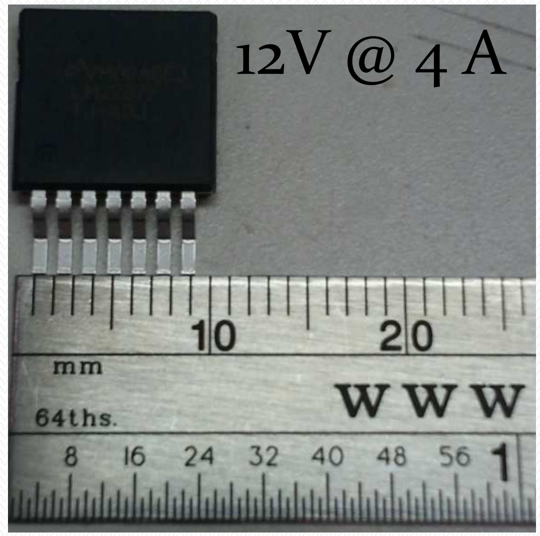
Power – Linear vs. Switching

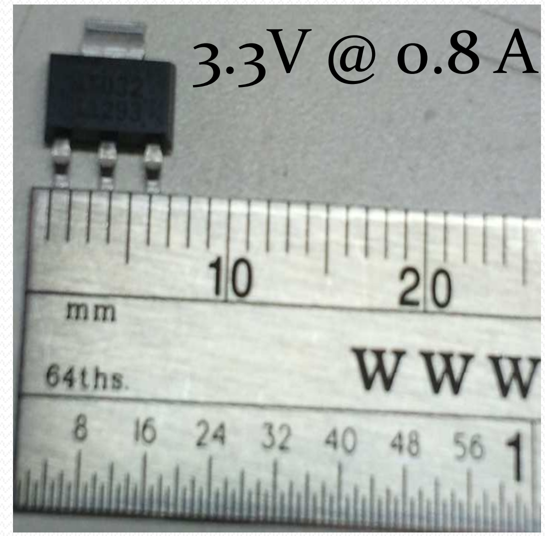
- Linear
  - High Efficiency when Vin-Vout is small
  - Low Noise
  - Dissipates Heat
- Switching
  - High Efficiency
  - Low Heat Dissipation
  - More Complex
  - Switching Ripple

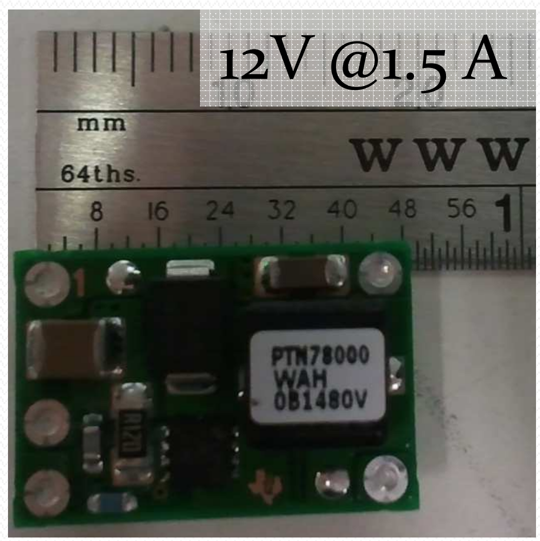
Regulator	Input (V)	Output (V)	Output (I)	Type
1	25	12	2.5	Switching
2	25	12	0.5	Switching
3	25	8	0.5	Switching
4	25	5	2.0	Switching
5	5	3.3	0.3	Linear

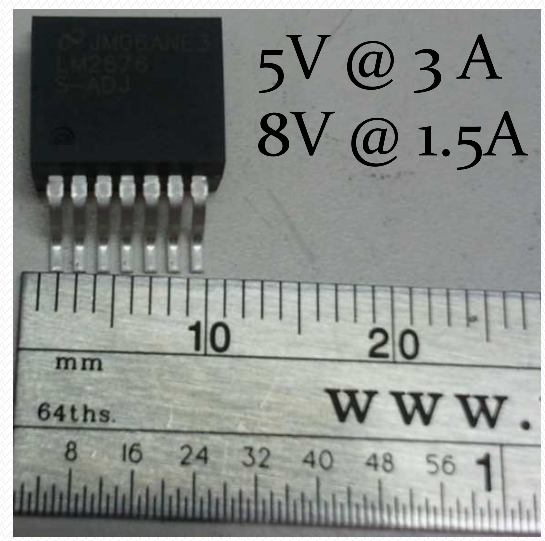
Power – Linear vs. Switching

Power	Devices
12V @ 4 A	Emer. Stop Relays Stereo Vision LIDAR Wireless Bridge
12V @ 1.5 A	Power Relays
8V @ 1.5 A	Compass Cameras
5V@ 3 A	FPGA GPS Display RC Receiver Microcontroller Servos General IC's
3.3V @ 0.8 A	Xbee Wireless



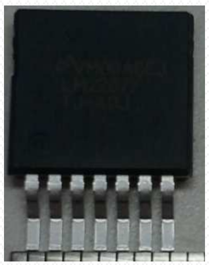


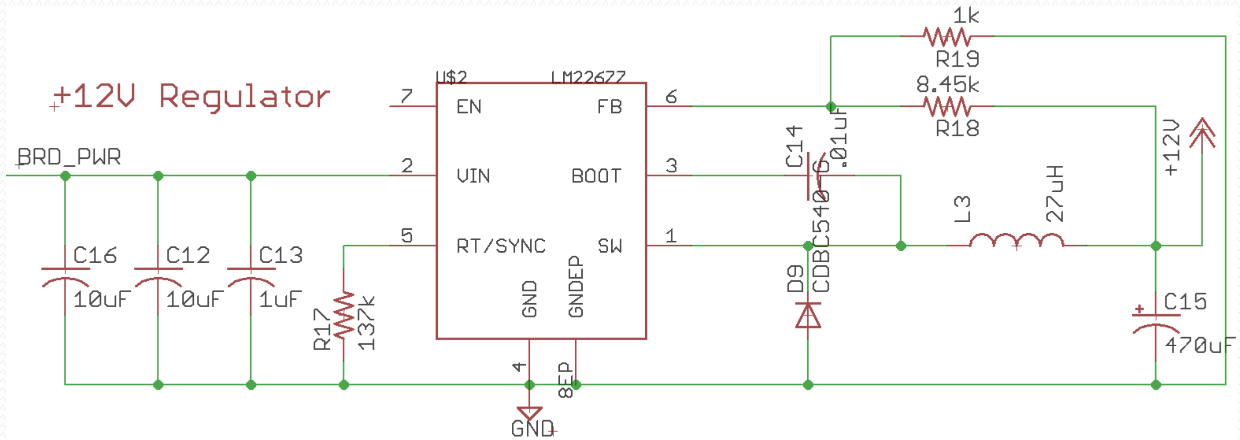




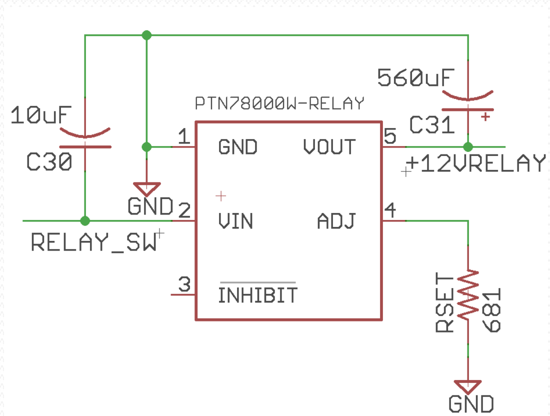
Power - Regulator Complexities

12V @ 4 A

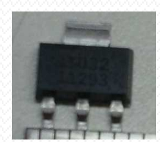


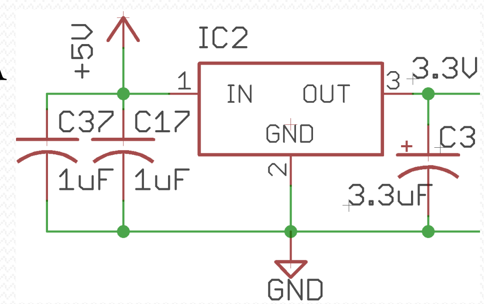


12V @ 1.5 A



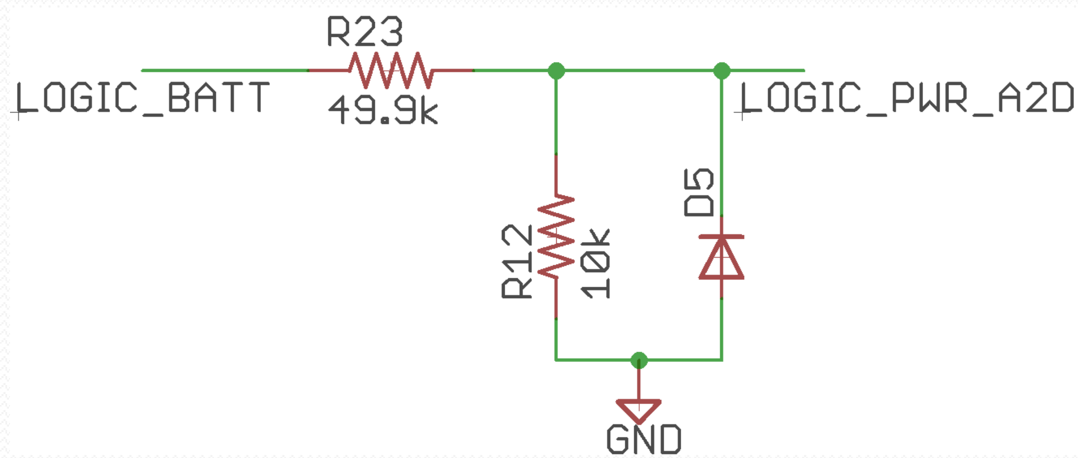
3.3V @ 0.8 A





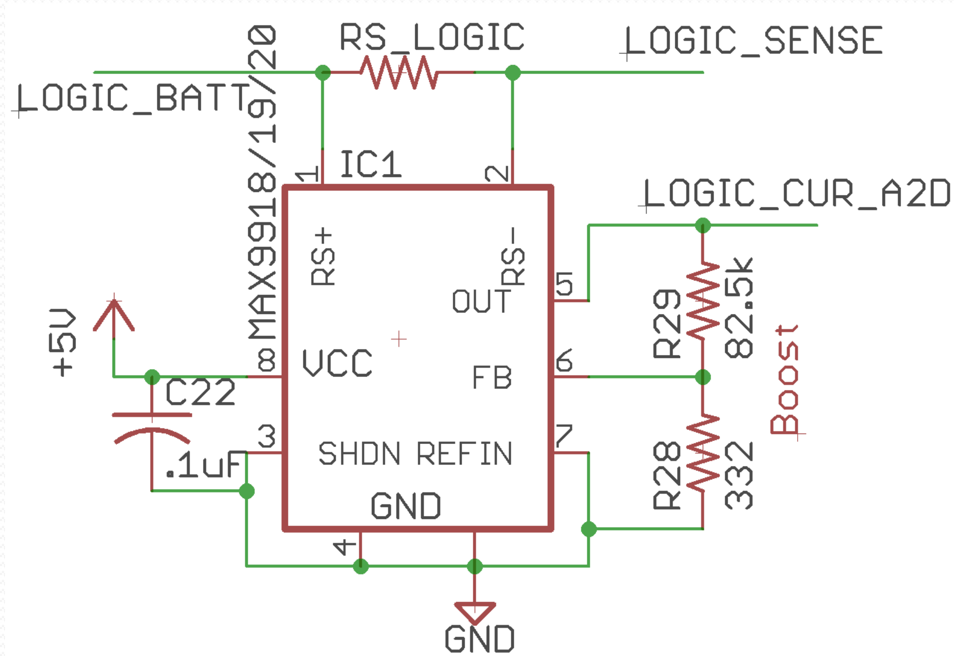
Sensing - Voltage

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



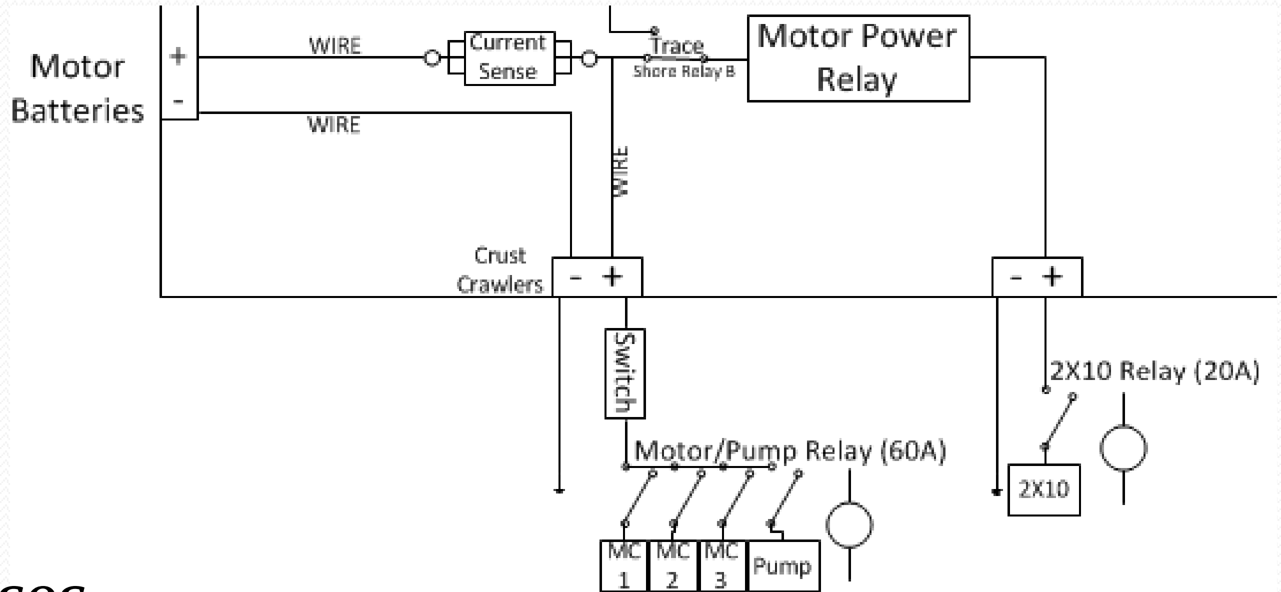
Sensing – Current – Shunt Resistor

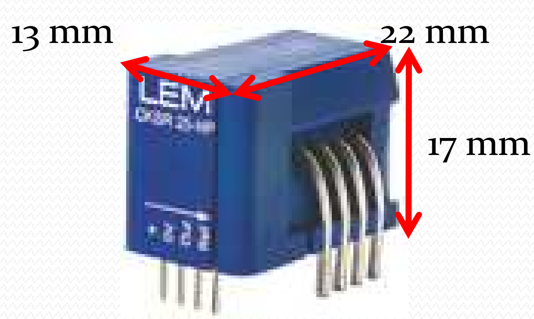
- Accurate
- Low Cost
- Adjustable Gain
- Sense Resistor = 0.005 Ω
- Insertion Losses
- Logic – 15 A Max
- Shore – 30 A Max



Sensing – Current - Hall Effect

- Motor Power
- Higher Current
  - 15 A Nominal
  - 51 A Max
- Higher Cost
- No Insertion Losses
- Voltage Output
- Exposed Leads

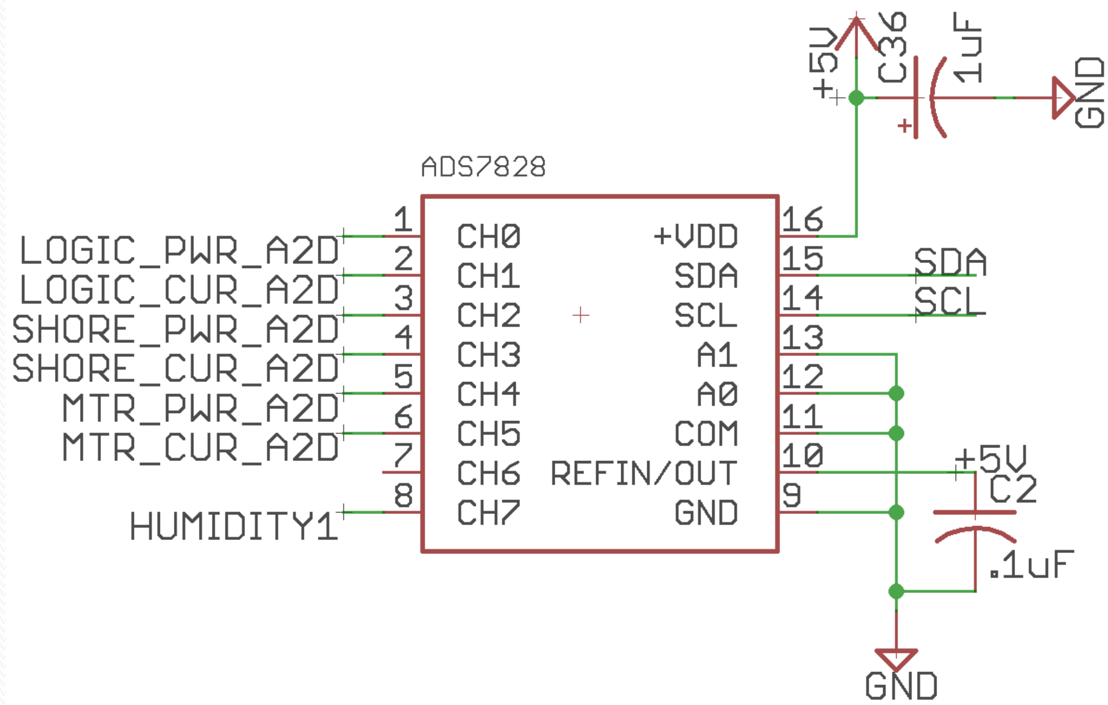




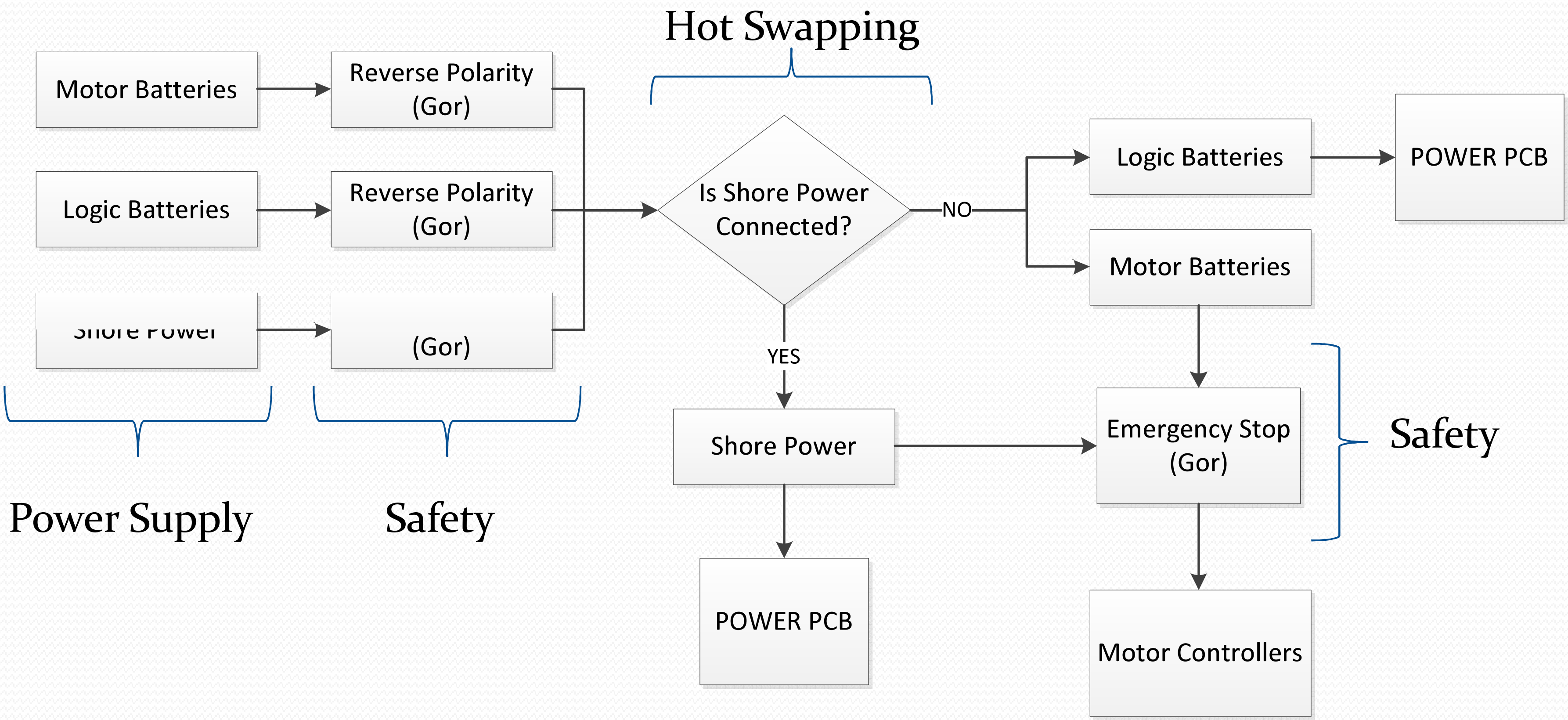
LEM-CAS-15-NP

Sensing – Analog to Digital

- 12-Bit A2D
- I²C Interface
- Close Proximity to Sensors



Power Flowchart



Reverse Polarity

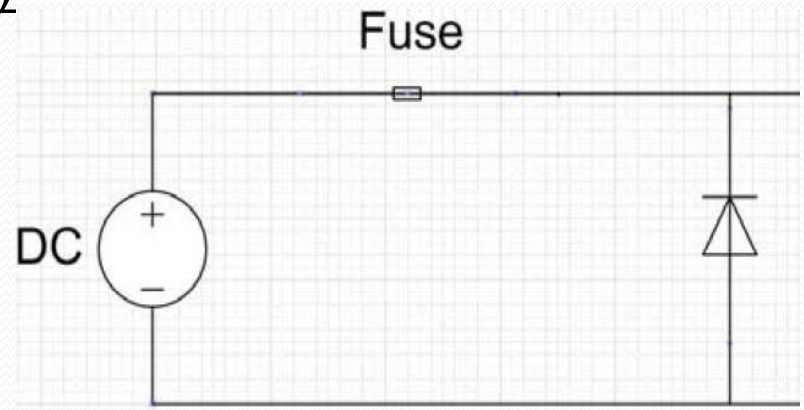
- Maximum 0.2 V drop across the reverse polarity circuit
- Needs to be implemented for all power sources
- Current ratings for the different power sources

Source	Maximum Current
Logic Battery	15 A
Shore Power	30 A
Motor Battery	60 A

Reverse Polarity

Fuse-Diode (Parallel Configuration)

- 0 V drop across diode
- Negligible total loss



Known Issues

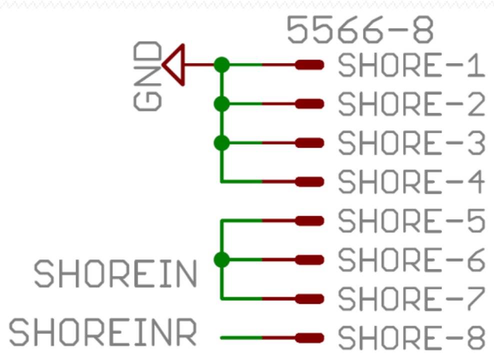
- Proper Fuse and Diode selection is critical
- Diode:
  - 220 A surge current for 8.3ms
- Fuse:

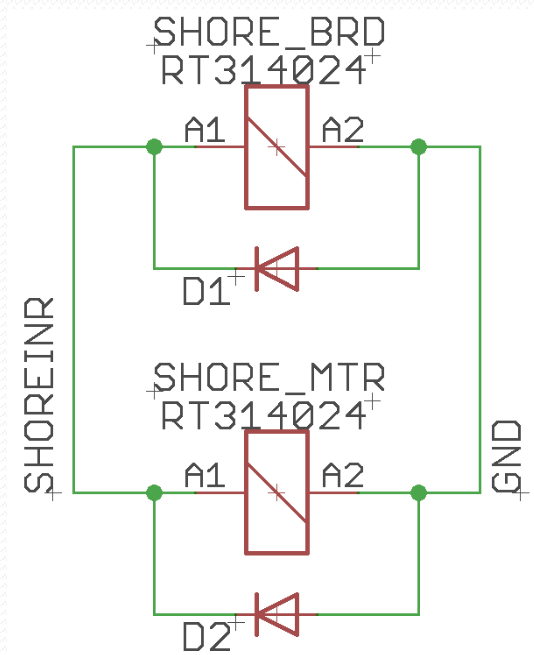
Fuse Rating (%)	Opening Time
110	100hrs
200	0.15s
350	0.080s
600	0.030s

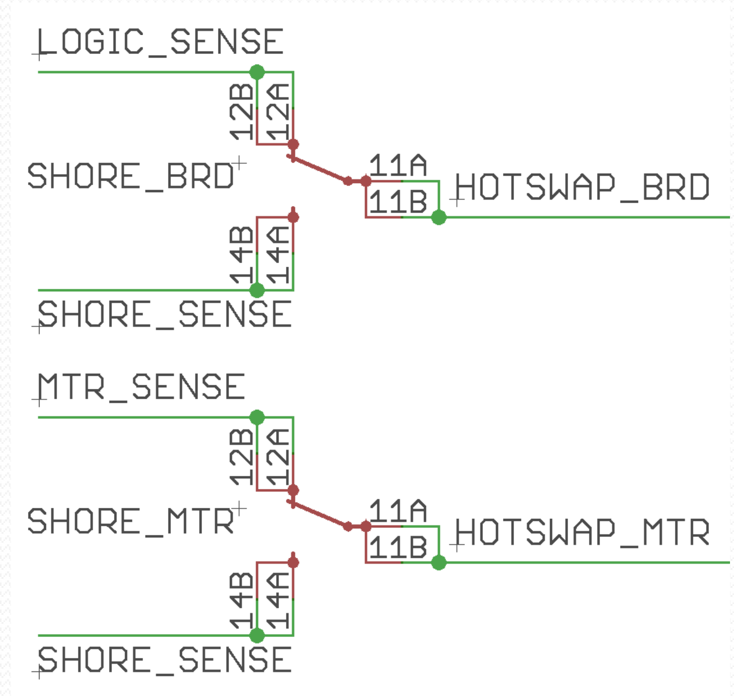
Hot Swapping

Relay Method:

- Practically lossless
- Very reliable







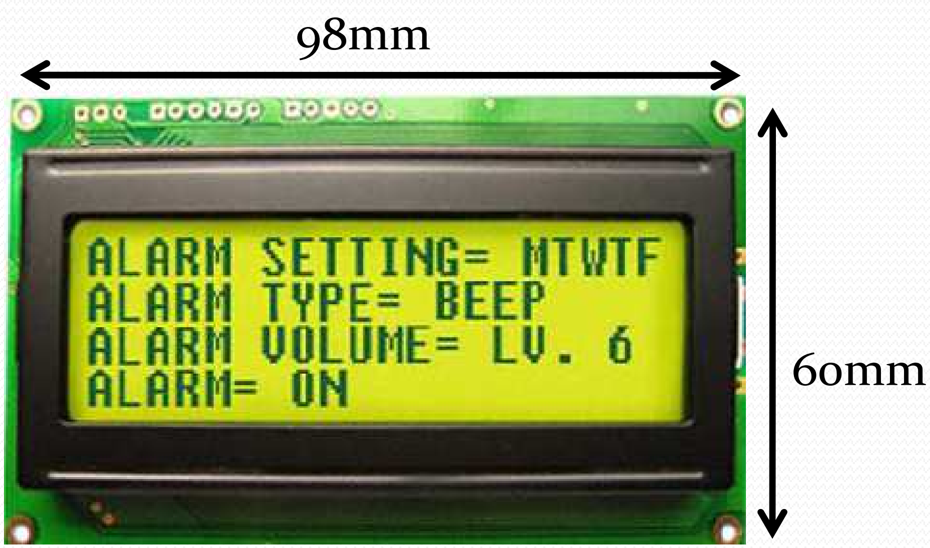
Display

Our Requirements:

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

Implementation:

- Mount LCD on electronics box
- Use waterproof buttons for control

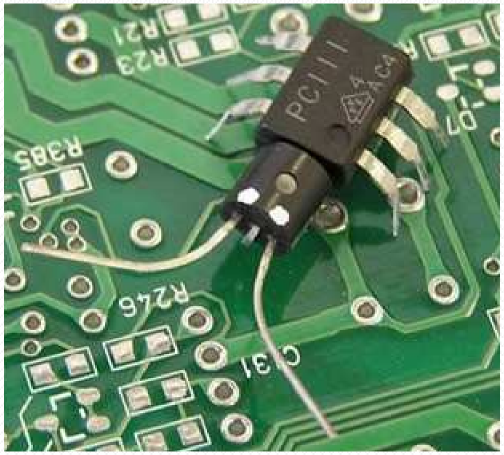


Screen	Display
1) Shore power details	Shore: xx.xx V xx.xx A xx.xx W System:_xx__xxx_min
2) Logic battery power details	Logic: xx.xx V xx.xx A xx.xx W System:_xx__xxx_min
3) Motor battery power details	Motor: xx.xx V xx.xx A xx.xx W System:_xx__xxx_min
4) Temperature and humidity	T1:xxx.x°C H1:xx.x% T2:xxx.x°C H1:xx.x% T:xxx.x°C - H:xx.x% System:_xx__xxx_min
5) Test	N/A

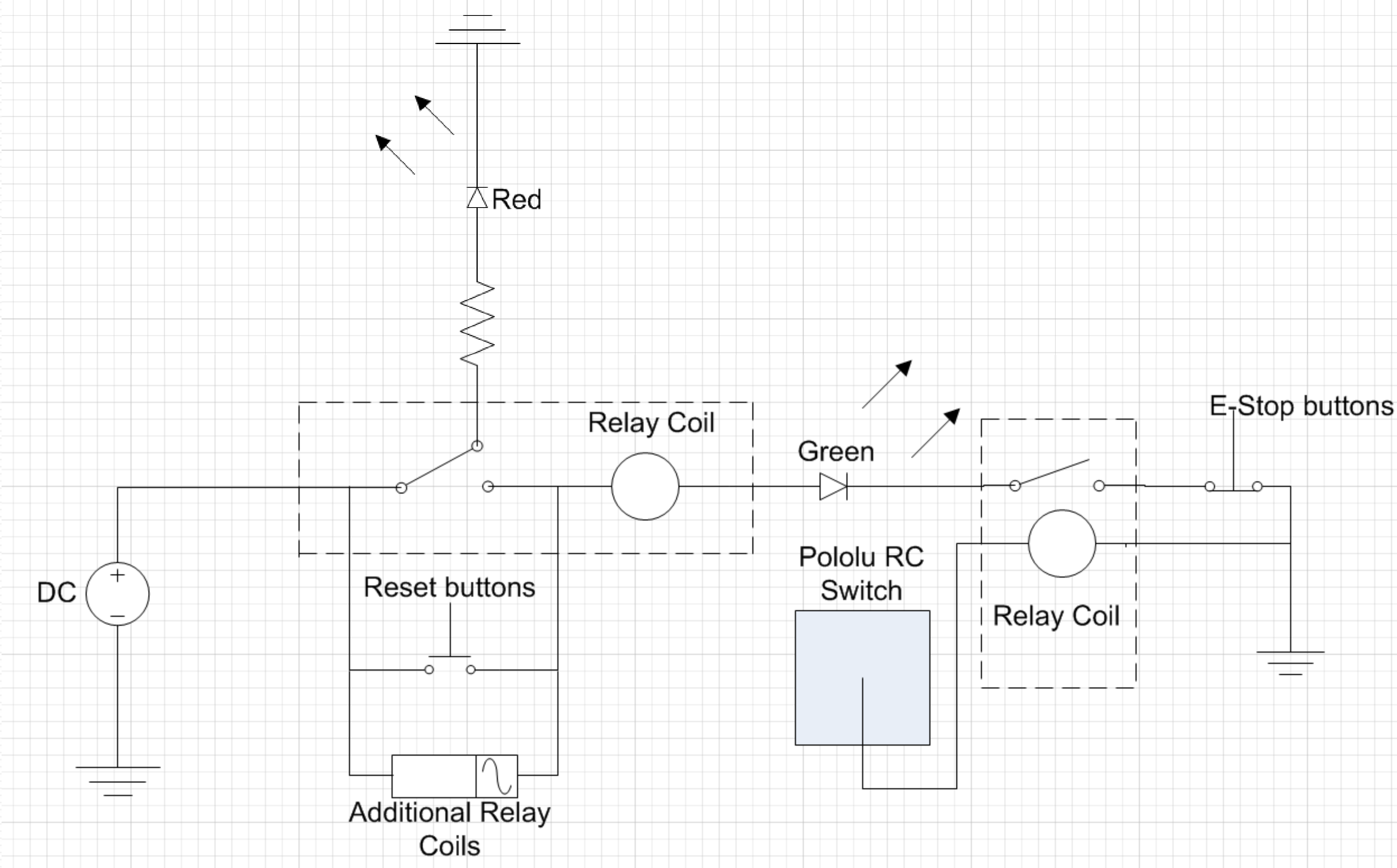
E-Stop Requirements

- Use minimum logic devices
- Must disengage all moving parts
- 2 reset buttons
- 3 E-stop buttons (One remote)
- < 10 W power dissipation
- E-Stop state indicators
- Digital output for Microcontroller

This year we will avoid **bugs** on the circuit

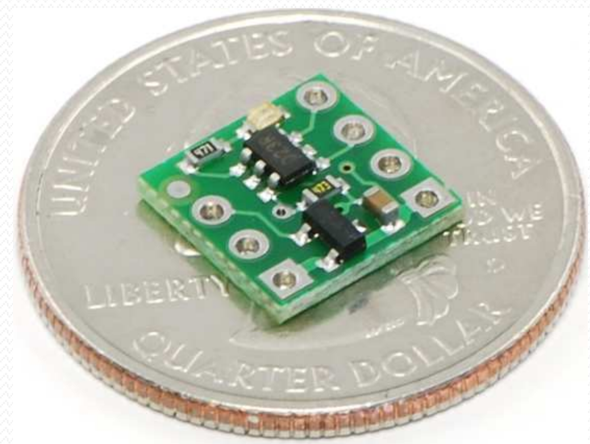


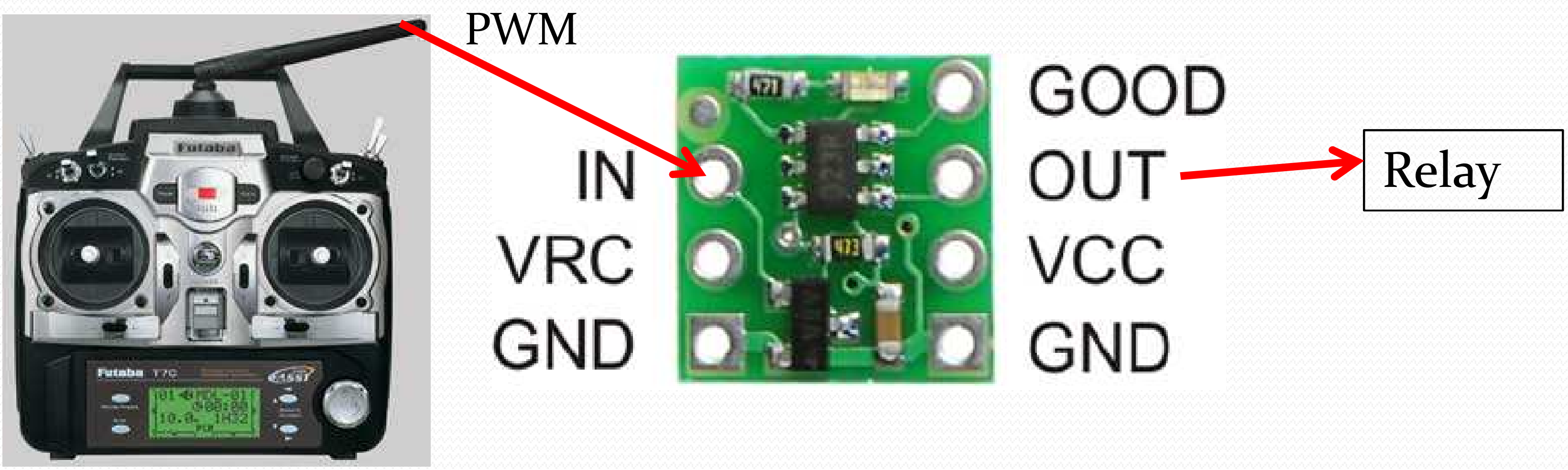
E-Stop Design



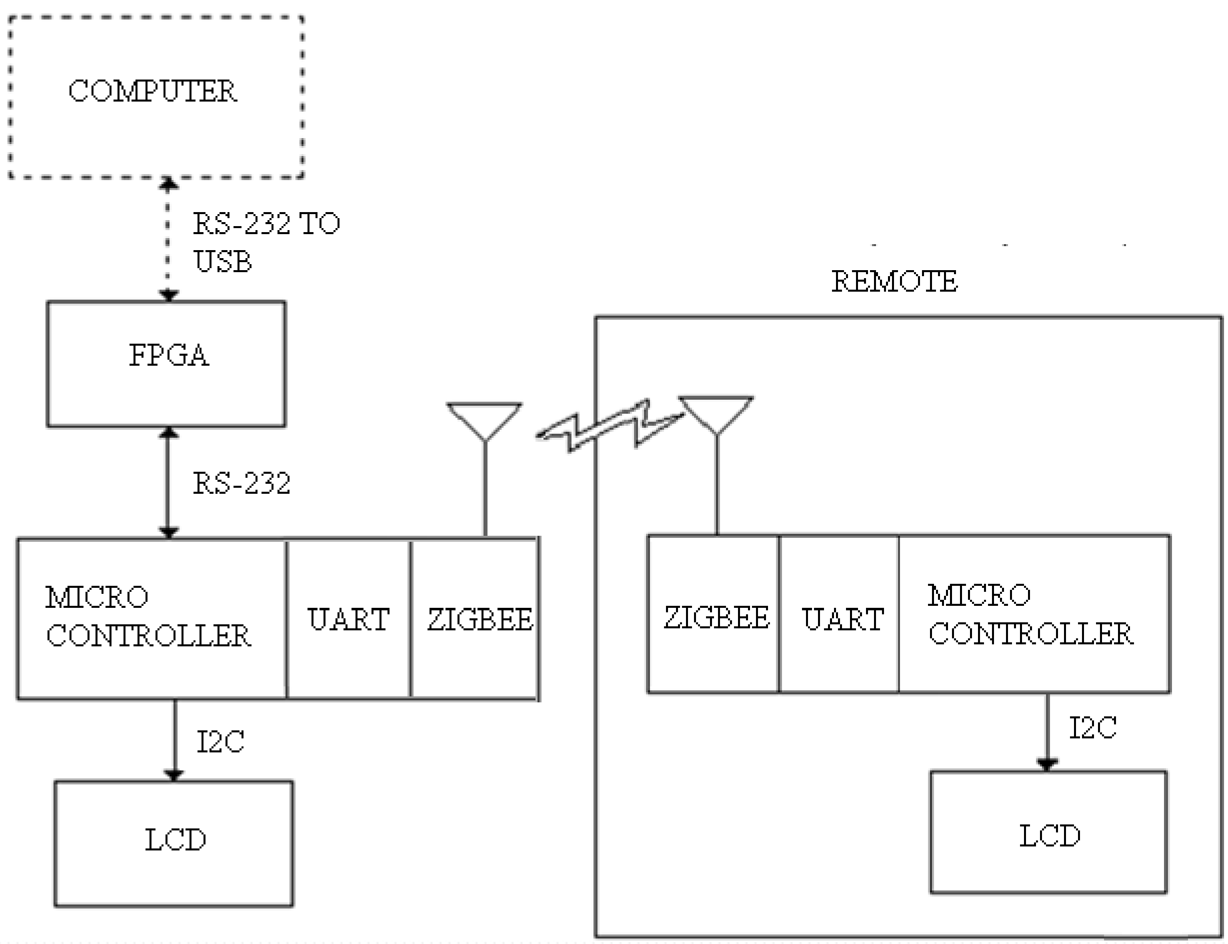
Pololu RC Switch

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





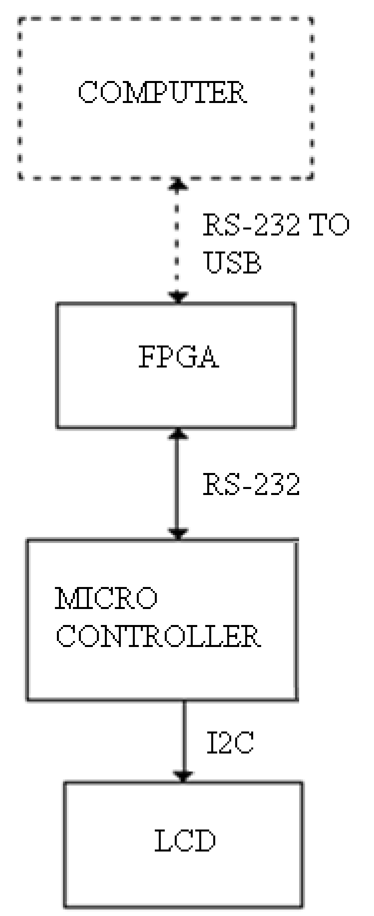
Wired/ Wireless Communication Platform



Wired Communication

<u>Our Requirements</u>

- Compatible with both desired and pre-existing components
- Capable of multi-master mode
- Works with our +5 V voltage values



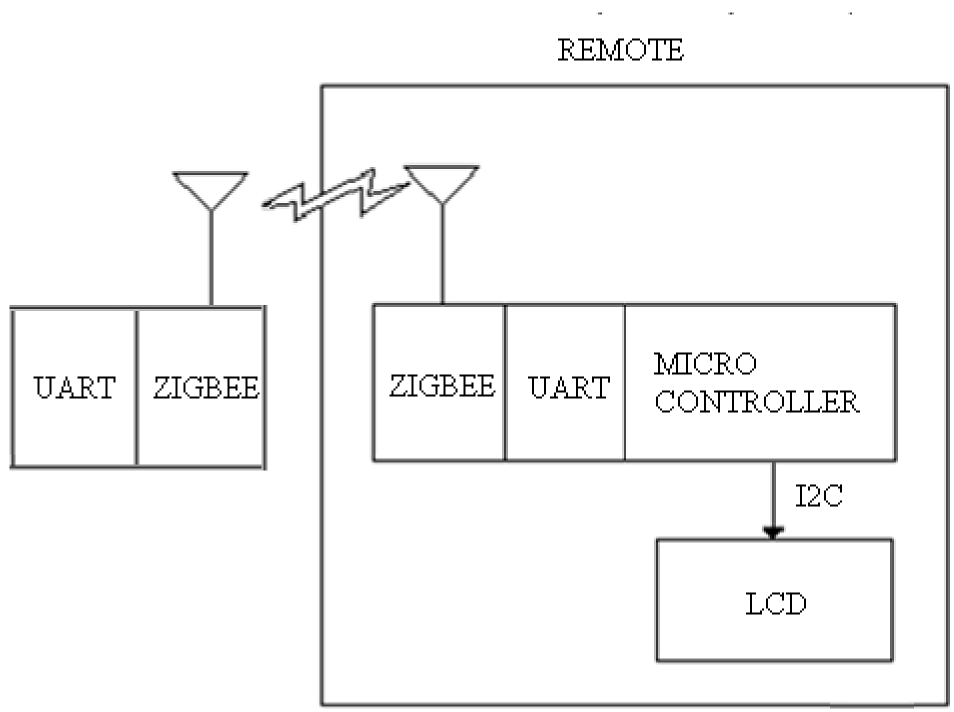
Wireless Communications

Our Requirements

- 900 ft open line of sight range
- Point-to-multipoint communication

Advantages

- Low transmitting power consumption (2 - 50 mW)
- Zigbee eliminates the need for another wired platform



Sensors

- The need to implement various sensors to the ASV

- Sensors to be implemented into our design include:
  - Temperature sensors
    - System feedback
  - Humidity sensor
    - System feedback
  - Light sensors
    - Challenges

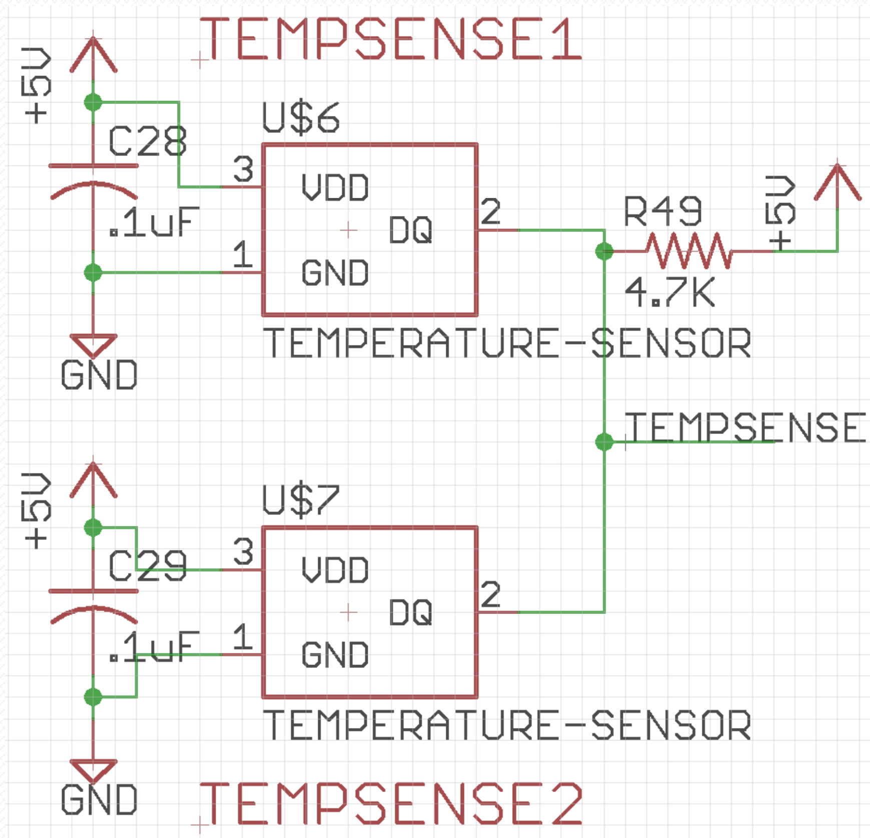
Temperature Sensor

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

Schematic

DS18S20



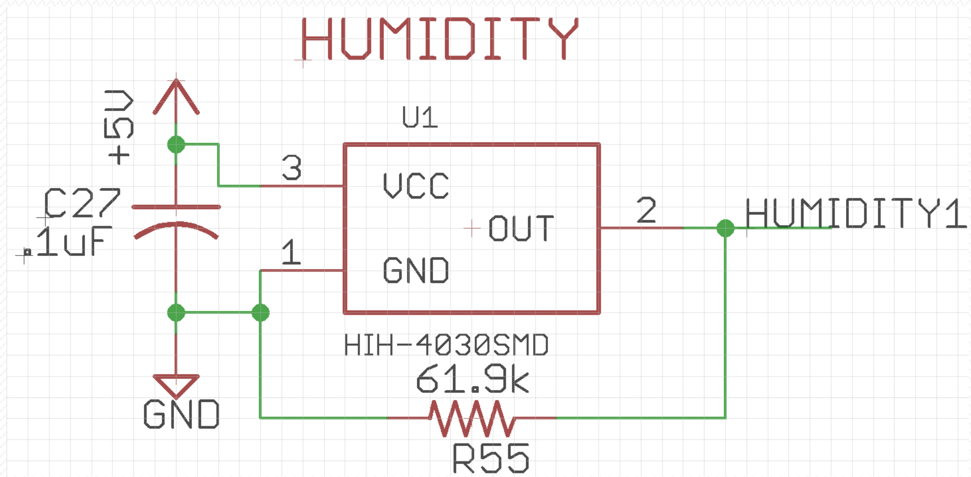
Humidity Sensor

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% RH

Schematic

HIH-5030



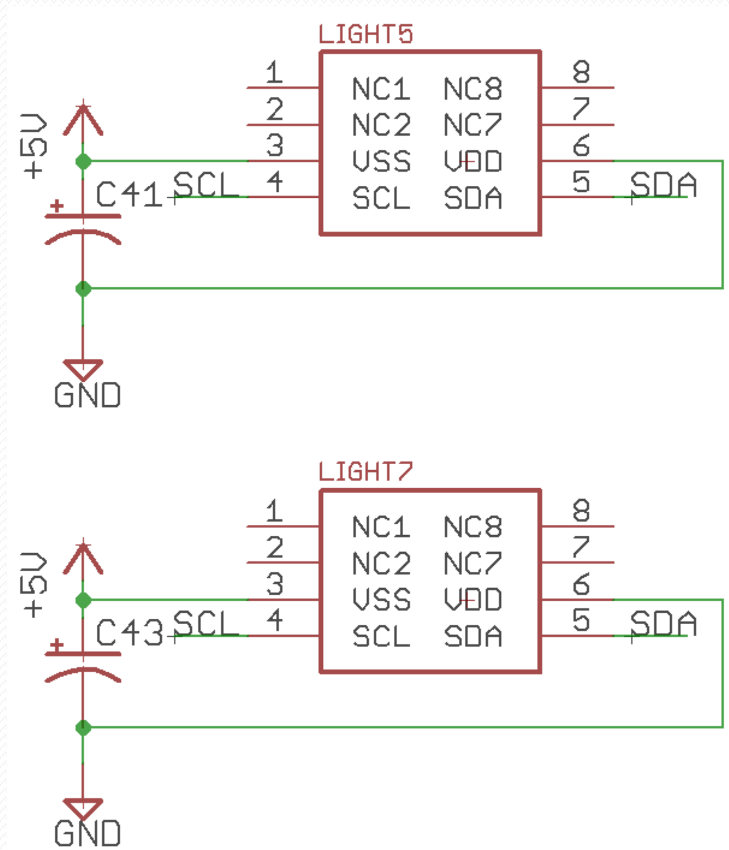
Light Sensor

Specifications

- I²C digital interface
- 16 bit ADC
- Capable of reading 0 to 100,000 lux

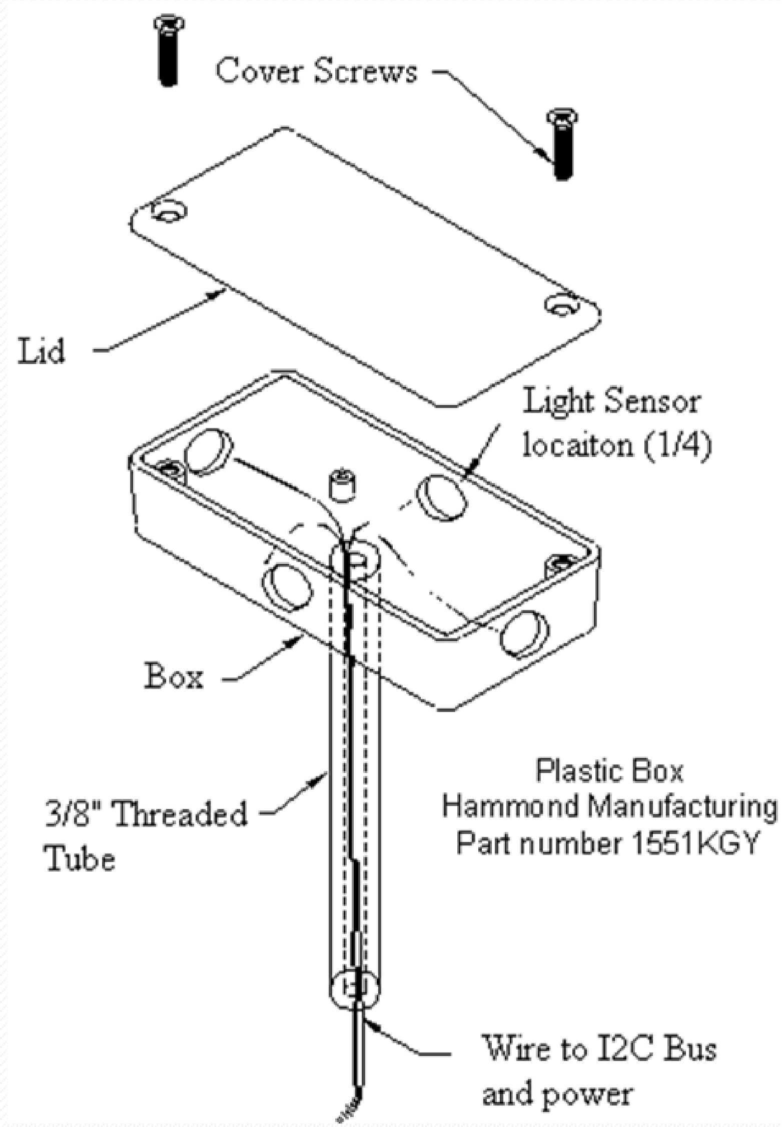
Schematic (4)

NOA1302



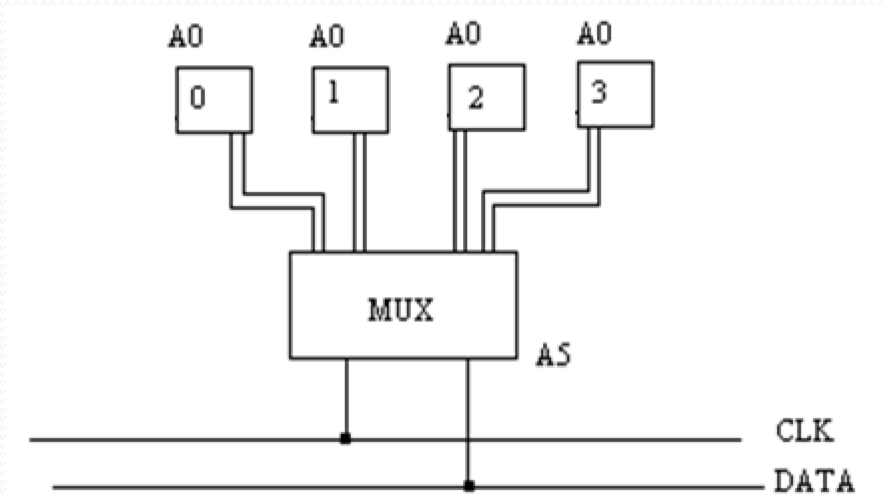
Light Sensor

- Location requires the box to be water resistant
- Ambient light reading
- NOA1302 are only addressable with 1 address
- Multiplexer Texas Instruments PCA9545A



Light Sensor - Addressing

The microcontroller will:



- Call A5 (Mux)
- Set port zero to high
- Ask for the reading
- Store the reading
- Repeat above steps but changing which port is high

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:

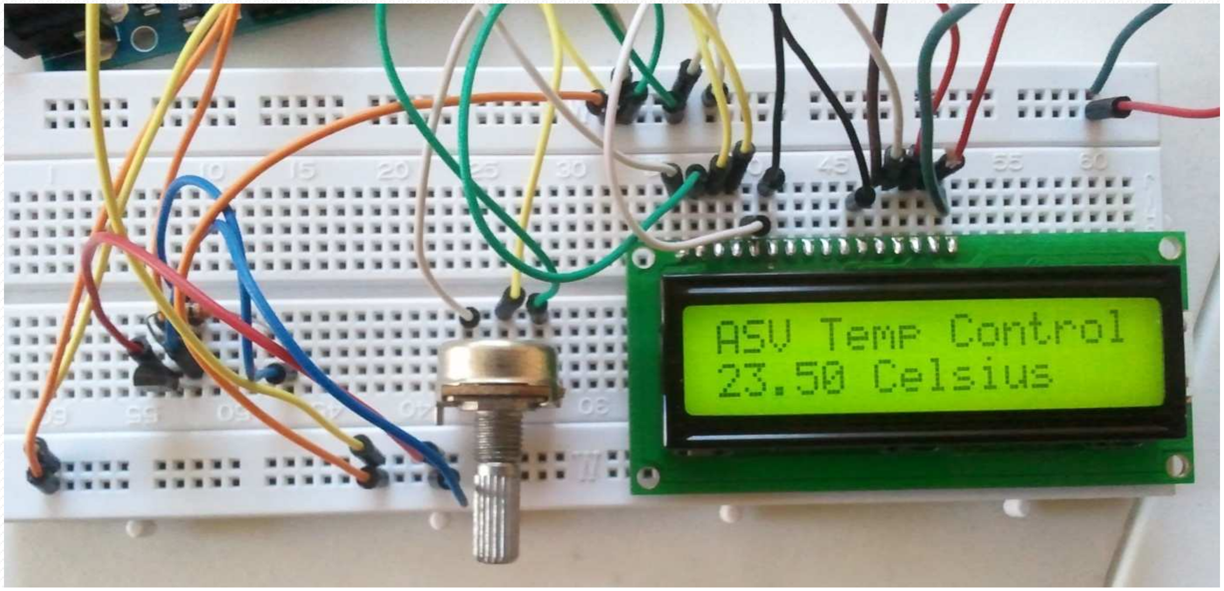
- Cost efficient
- Power Consumption is less
- Communication between devices is much easier.

Programming Environment

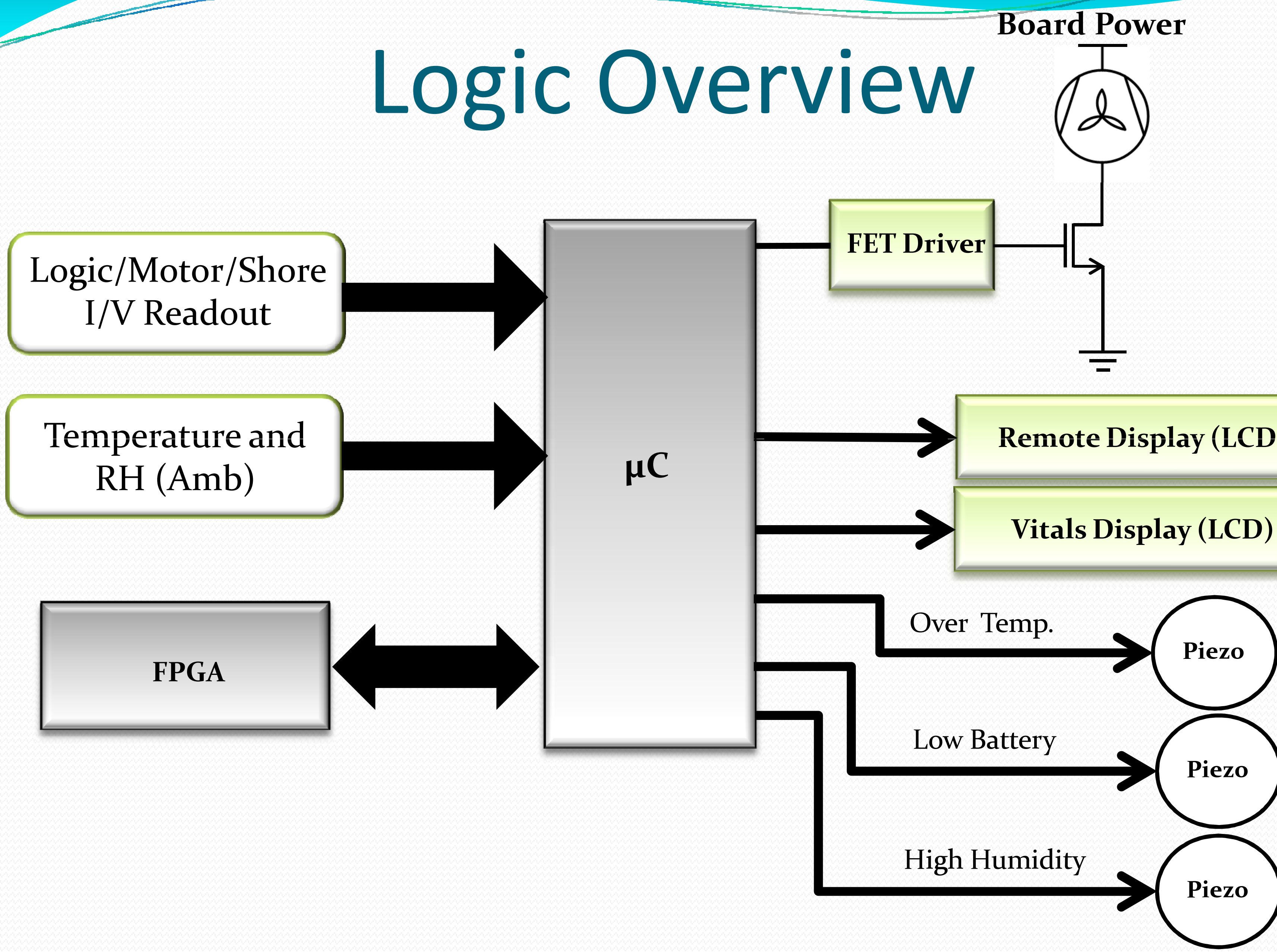
- Microcontroller
  - AVR Studio 4
  - AVR Programmer (ICSP)
  - C language
  - Windows/Linux
- FPGA
  - Xilinx ISE WebPack
  - JTAG Interface
  - VHDL language
  - Windows/Linux

Microcontroller – Atmega328p

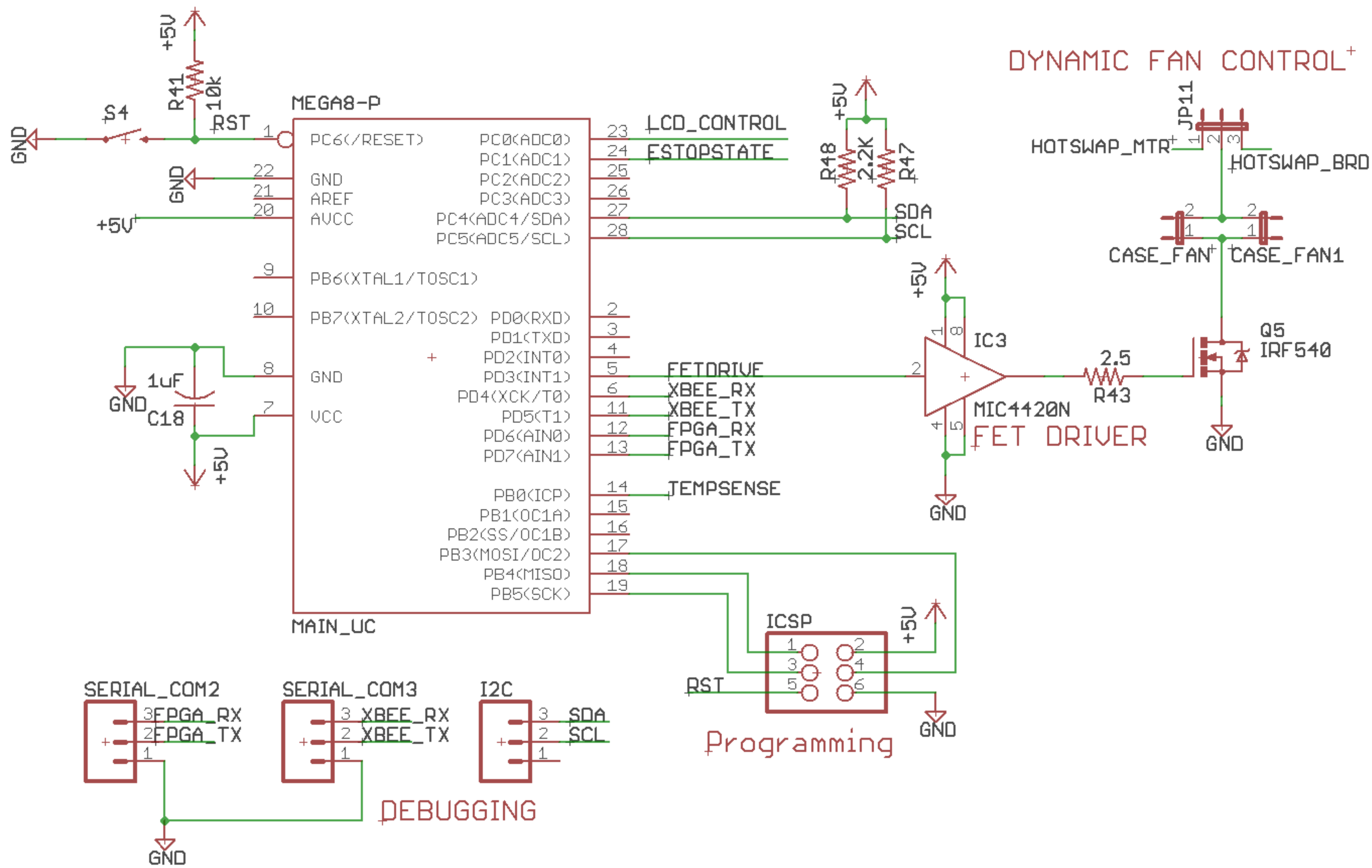
- Analog to digital conversion (Dedicated ADC as well)
- Display vitals on an LCD screen
- Regulate air flow through case based on ambient temperature in the case.
- Transmit data wirelessly to remote box by interfacing with a XBee



Logic Overview

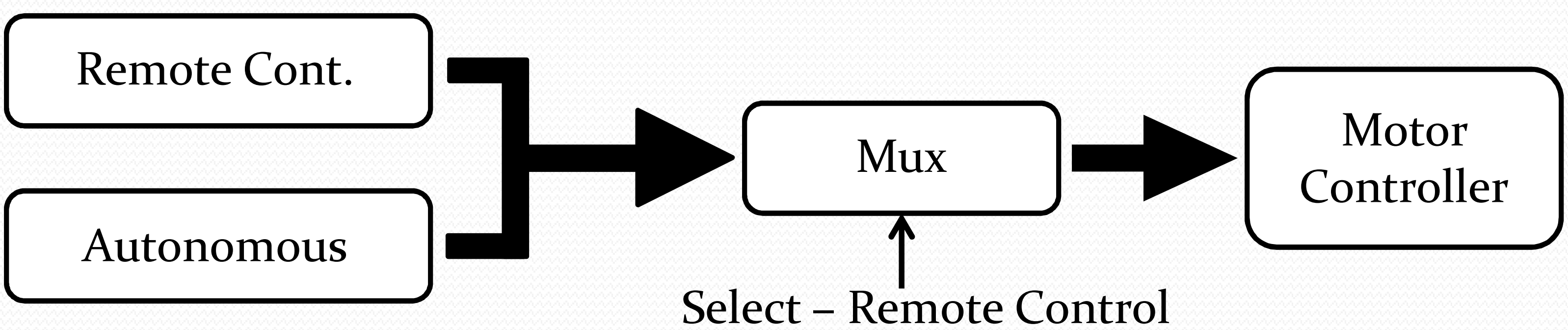


Microcontroller - Schematics

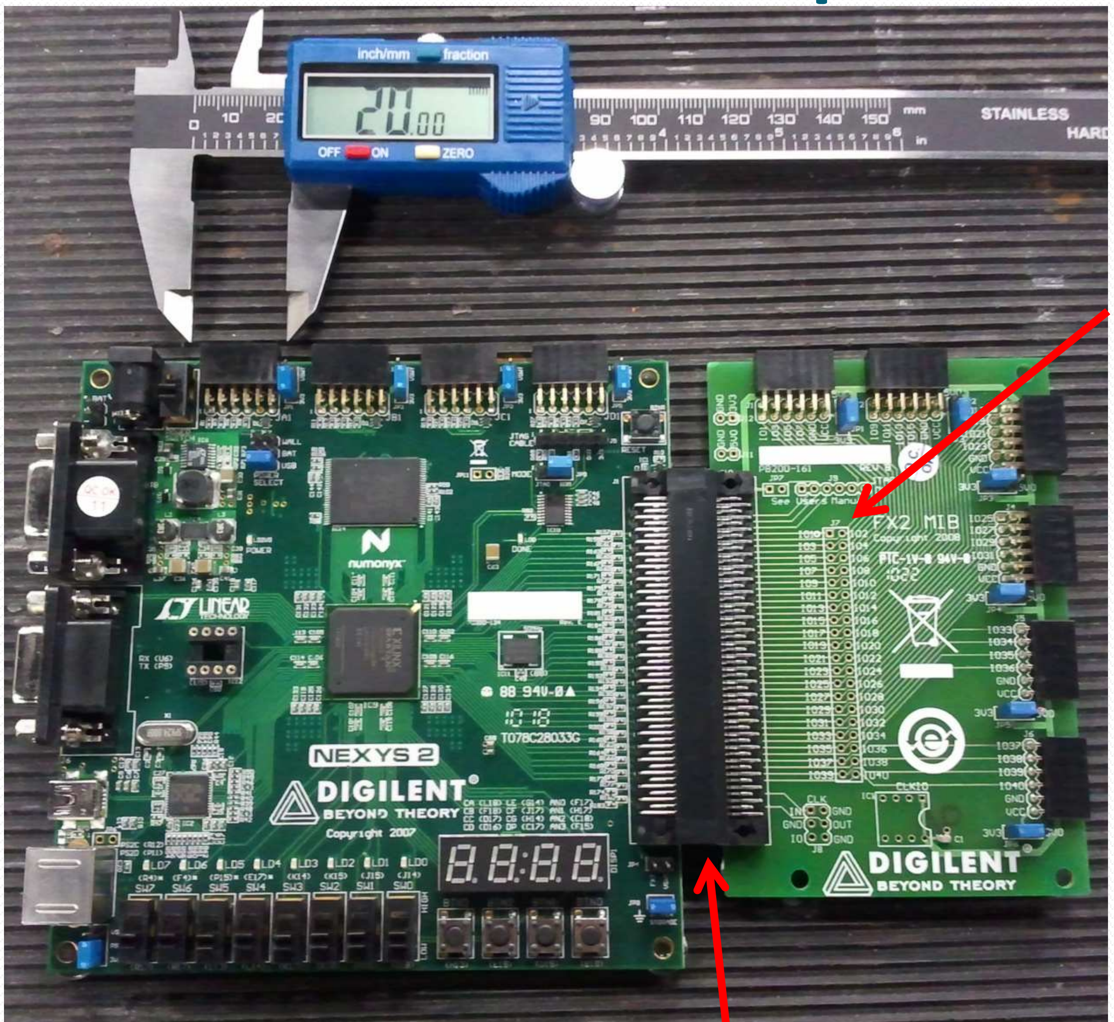


FPGA – Xilinx Spartan 3E

- 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



FPGA – Snapshot



40 Pin IDE Connector to PCB

FX2 Connector

Timeline

Item	Due Date	Progress
Research	12/04/2010	100%
Schematic/Design	01/25/2011	95%
Board Layout	01/30/2011	5%
Board Population	02/19/2011	0%
Board Testing	02/26/2011	0%
Mechanical Assembly	02/26/2011	40%
Integration	03/05/2011	10%

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