ECE ILLINOIS

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

Otter Print Shooter

Sabrina Cheng
Sze Yin Foo
Hoong Chin Ng

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Agenda

- Objectives
- Device Overview
- Features and Benefits
- Hardware Modules and Testing
  - Control Unit
  - Imaging Module
  - Force Sensing Module
  - Motion Sensing Module
  - Lighting Module
  - Power Unit
  - Container and Lid
- Other Tests
- Success
- Recommendations
- Ethical Considerations

Objectives

- Assist Illinois Natural History Survey in collecting biometrical data of otters
- Facilitate the identification of individual otters and get a count of otters

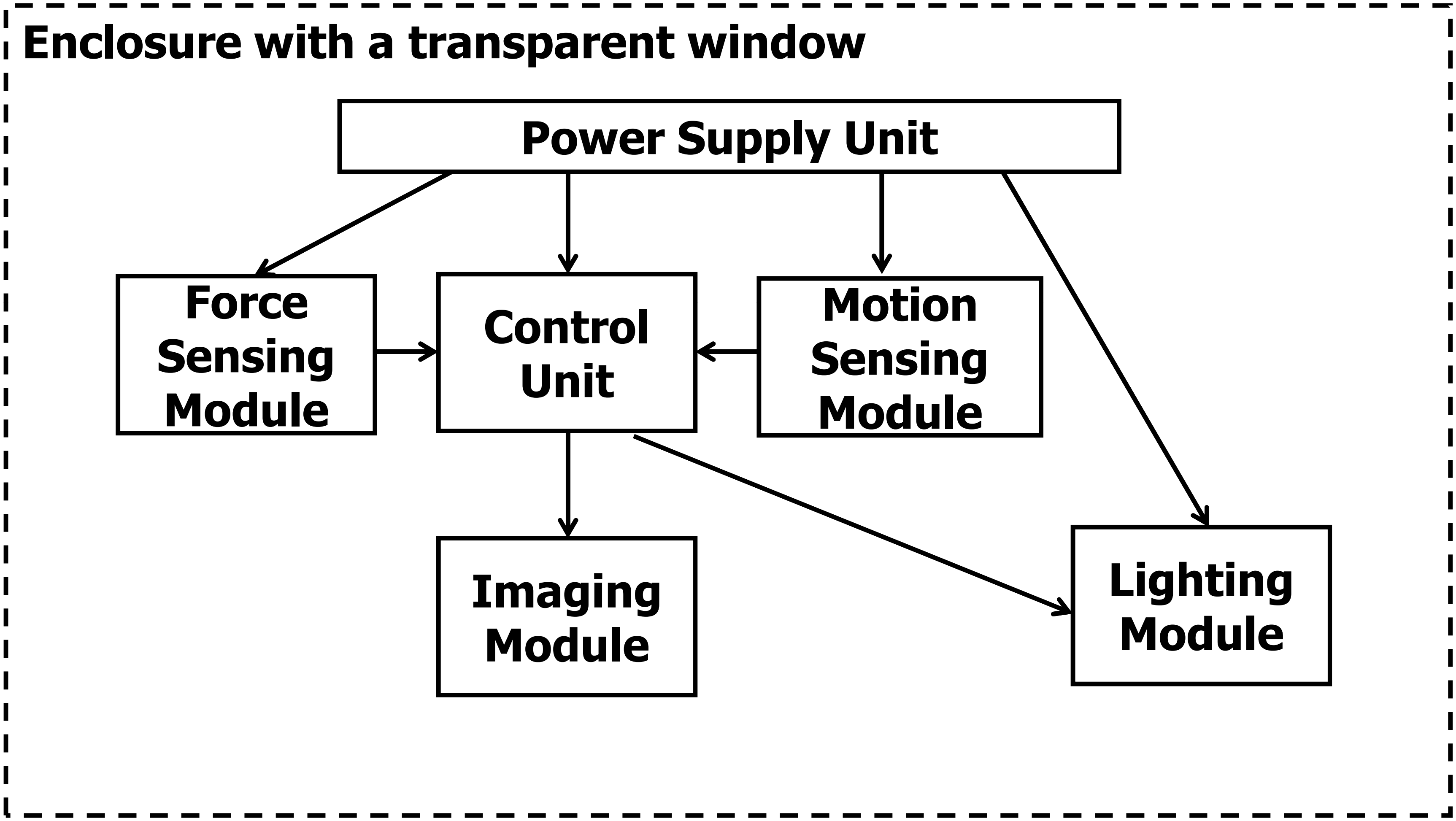
Device Overview

- 23″ L x 15″ W x 21″ H
- A transparent window on the top
- Activates when an otter steps on the window
- A DSLR camera captures the otter's footprint
- LEDs provide illumination

Features and Benefits

- Captures high-detail images of otter footprints
- Records the date/time of otter activities
- Operates independently without human intervention
- Lasts at least four days

Block Diagram

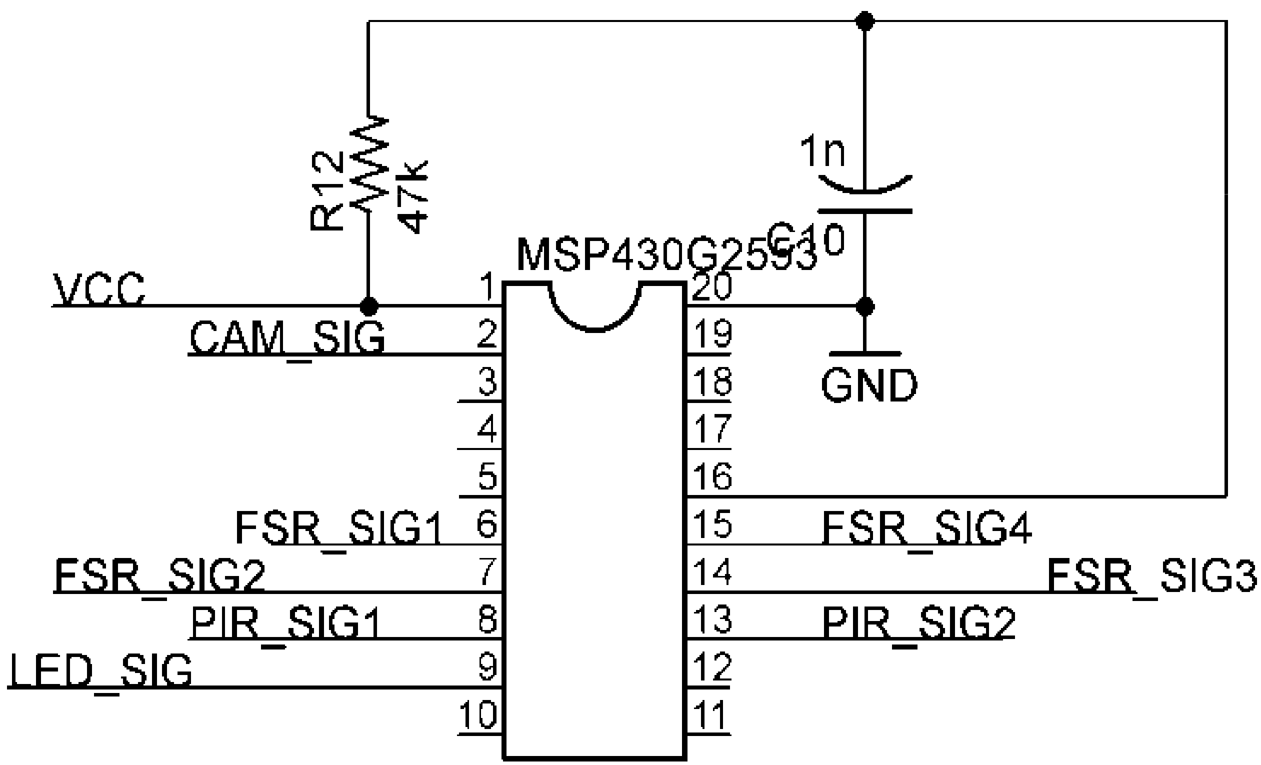


Control Unit

- TI MSP430G2553 microprocessor
- Ultra low power consumption
  – Otters are only active on land for a few hours
- Fast wake-up time
  – Minimizing response time

Control Unit

Schematic of Control Unit



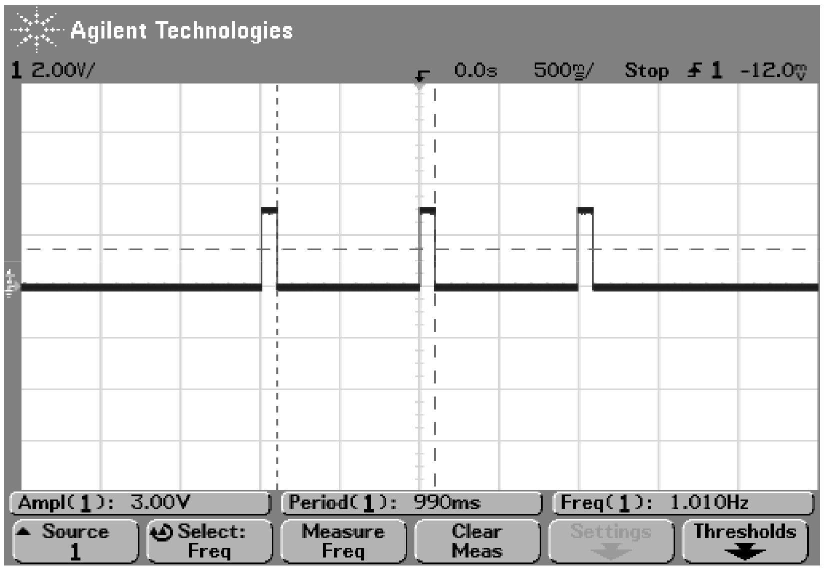
Control Unit

Workflow

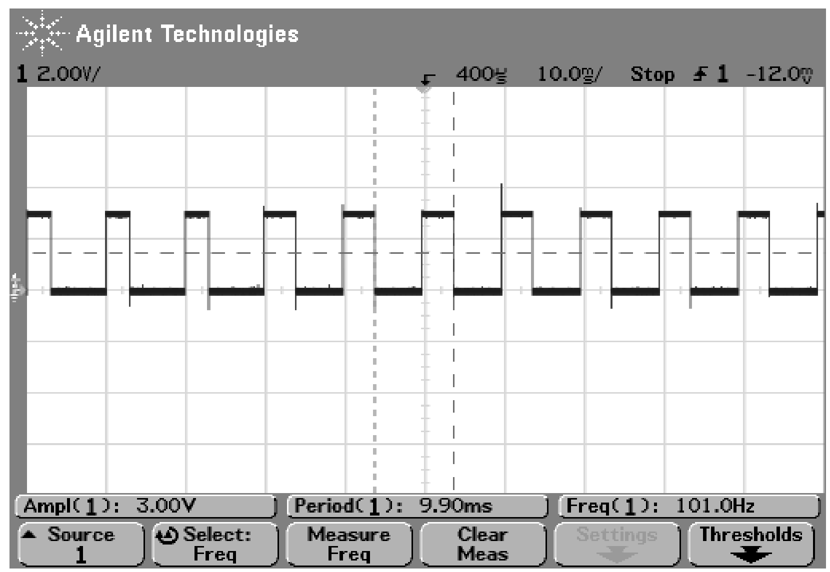
- Standby and waiting for input interrupt
- Motion triggers PWM output to lighting module
  - 0% to 80% duty cycles over 4 sec
  - Rest for 5 sec before next motion detection
- Force triggers lighting module and imaging module
  - One image per sec while force is applied

Control Unit

Measurement Results:



← 0.1 s digital pulses



PWM output with varying duty cycles →

Imaging Module

- **Camera**
  - Canon EOS Rebel T3 DSLR camera (12M) with 18-55 mm lens
- **Shutter Controller**
  - Vishay SFH618A optocoupler
  - Nikon and Canon interface cables

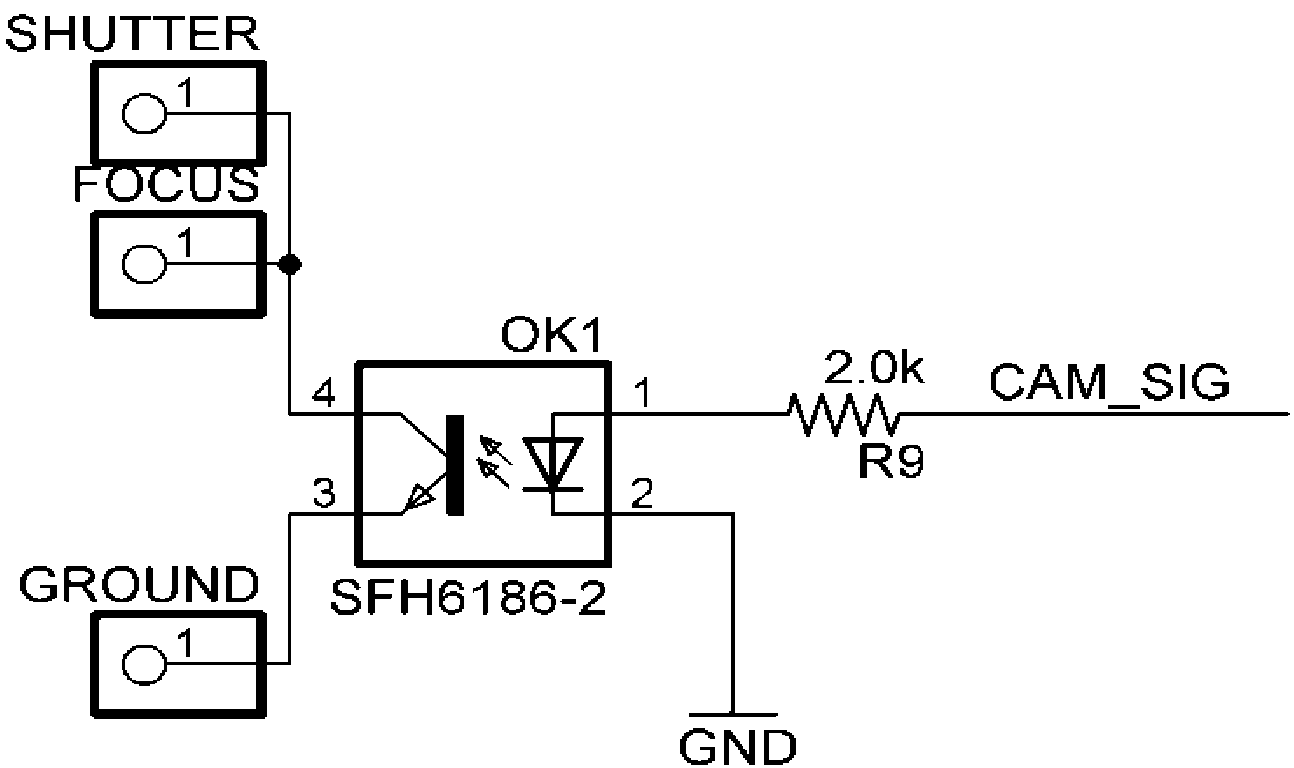
Imaging Module

Camera Setting

Parameter	Value
Focal Length	18mm
Focus	Manual
Shutter Speed	1/100 sec
Aperture	F 3.5
ISO Sensitivity	800
Image Format	JPEG

Imaging Module

Schematic of Shutter Controller

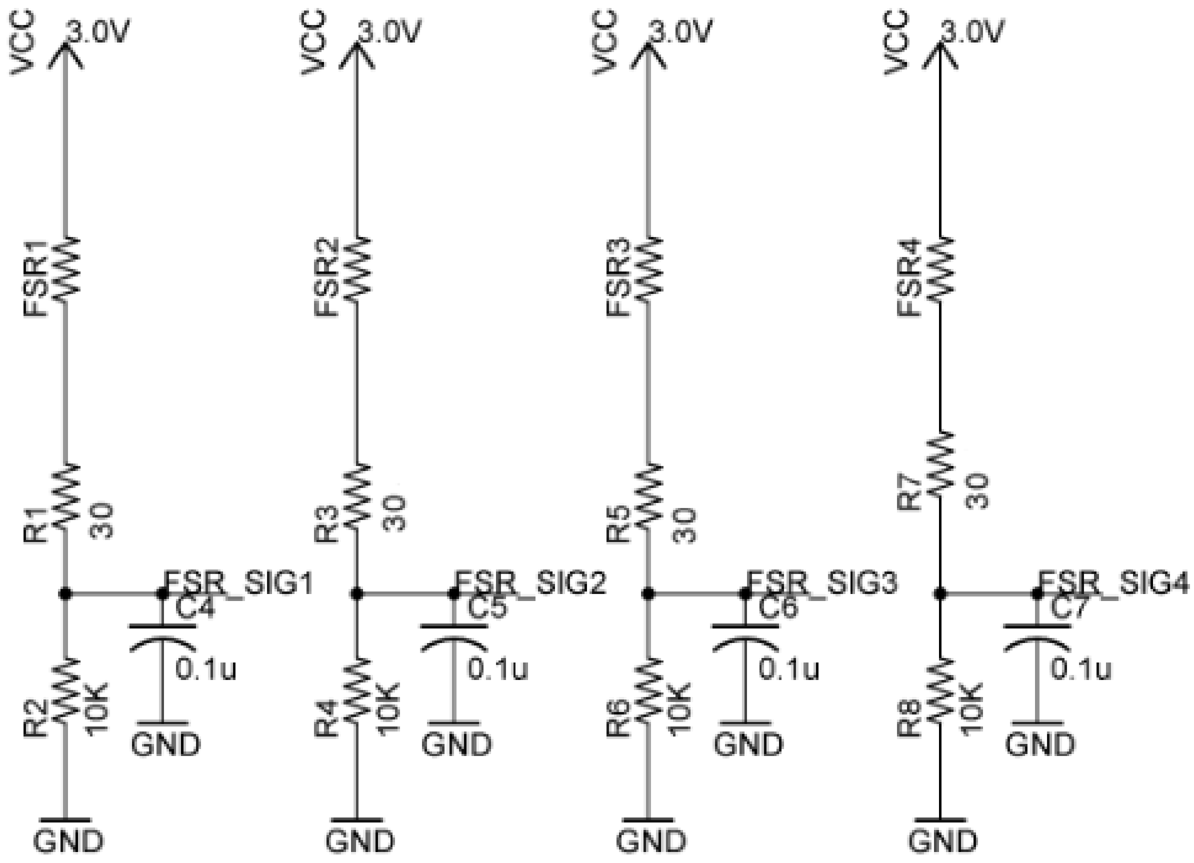


Imaging Module

Interface Connectors

Force Sensing Module

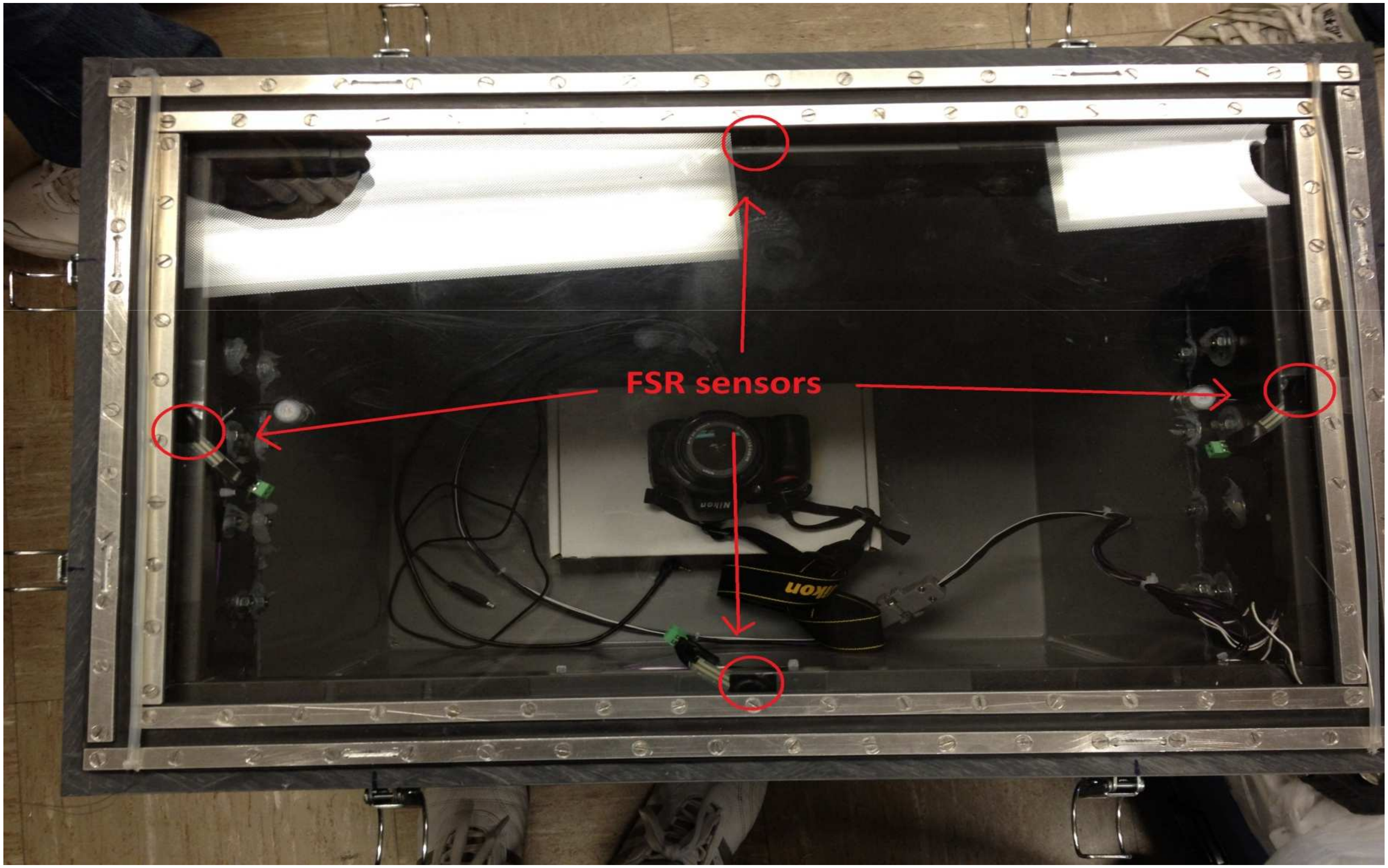
Schematic of Force Sensing Module



Design Challenges

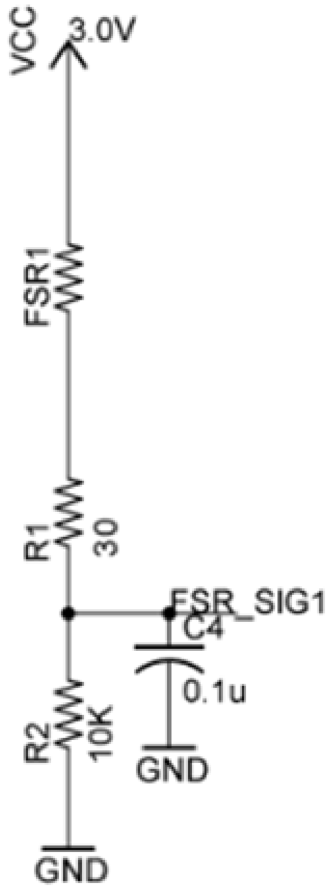
- Problem: Determine when the camera should capture a picture.
- Initial solution:
  - Place Force Sensitive Resistors (FSR) under the acrylic sheet.
- Solution:
  - Putting washer on top of the FSR to have a smaller point of weight.
  - Add tapes and foams so that the surface is leveled.

Force Sensing Module



Force Sensing Module

Calculation:



Voltage divider rule

$$Output\,Voltage = \frac{10K}{FSR + 10K + 30} \times 3V$$

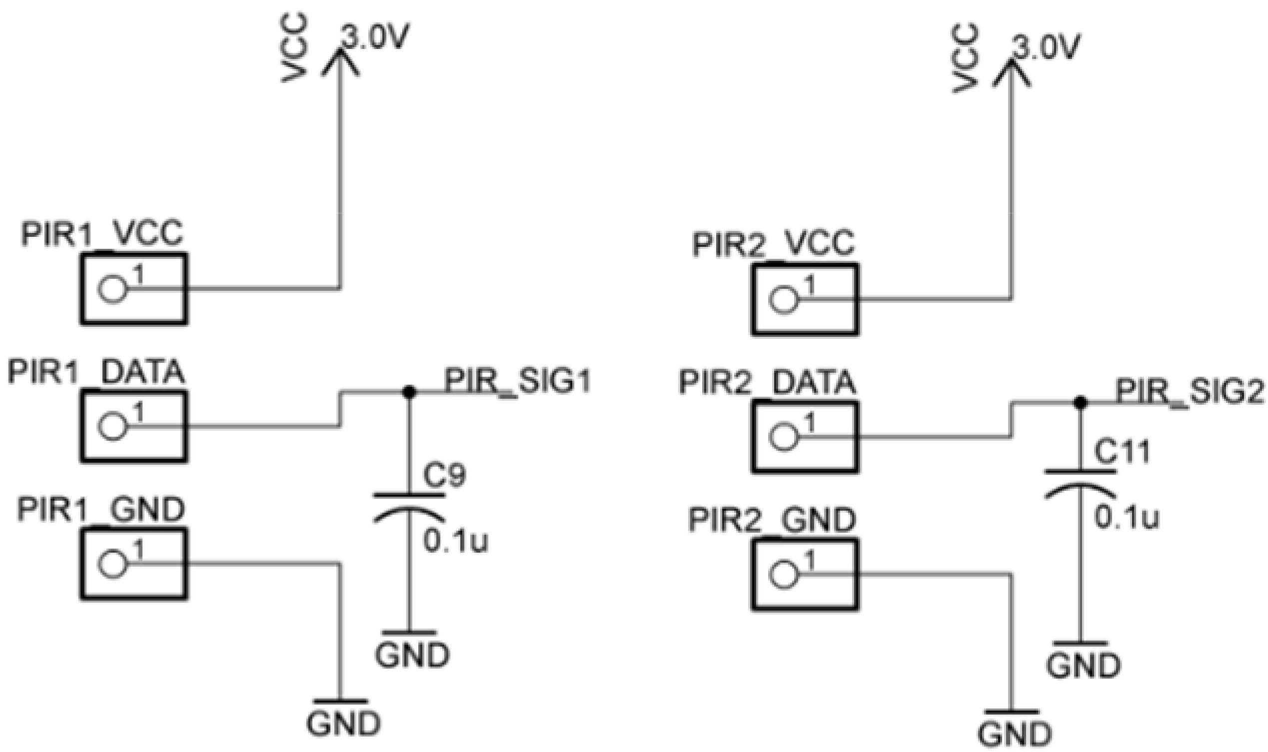
Force Sensing Module

Testing and Measurements:

FSR	Resistance		Output Voltage		Microcontroller	
	0kg	3kg	0kg	3kg	0kg	3kg
1	>1MΩ	5.3kΩ	~0V	1.957V	LOW	HIGH
2	235kΩ	3.3kΩ	0.122V	2.251V	LOW	HIGH
3	>1MΩ	4.8kΩ	~0V	2.023V	LOW	HIGH
4	118kΩ	3.1kΩ	0.234V	2.285V	LOW	HIGH

Motion Sensing Module

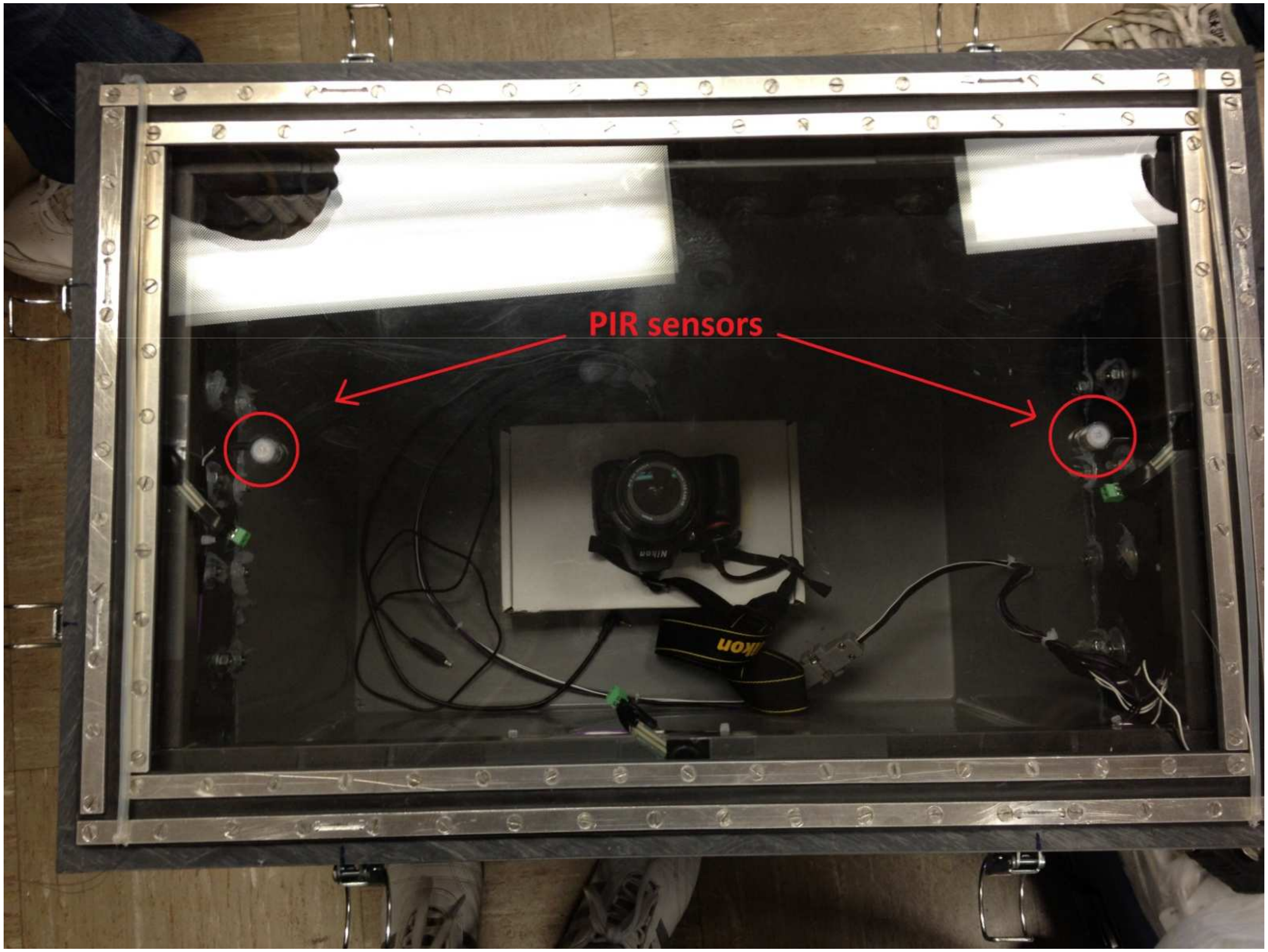
Schematic of Motion Sensing Module



Design Challenges

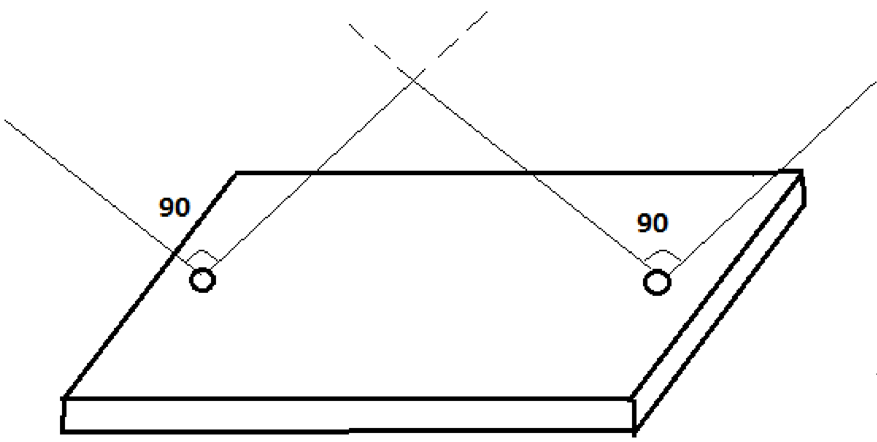
- Problem: Determine the presence of the otter.
- Initial Solution:
  - Place motion sensors (PIR) at the bottom of the container
- Solution:
  - Drill holes for the PIR sensors to be leveled with the surface of the plexiglass window.
  - Use 2 PIR sensors.

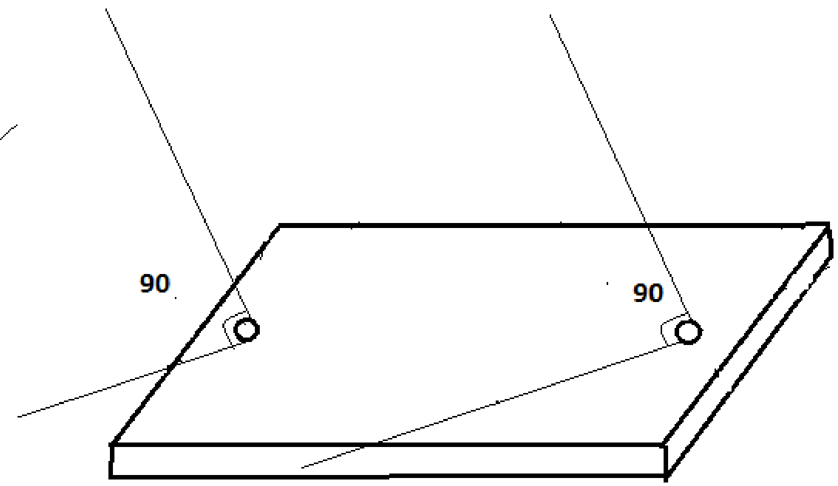
Motion Sensing Module



Motion Sensing Module

Horizontal and Vertical Detection Angle of 90° and Detection Range of 2m.

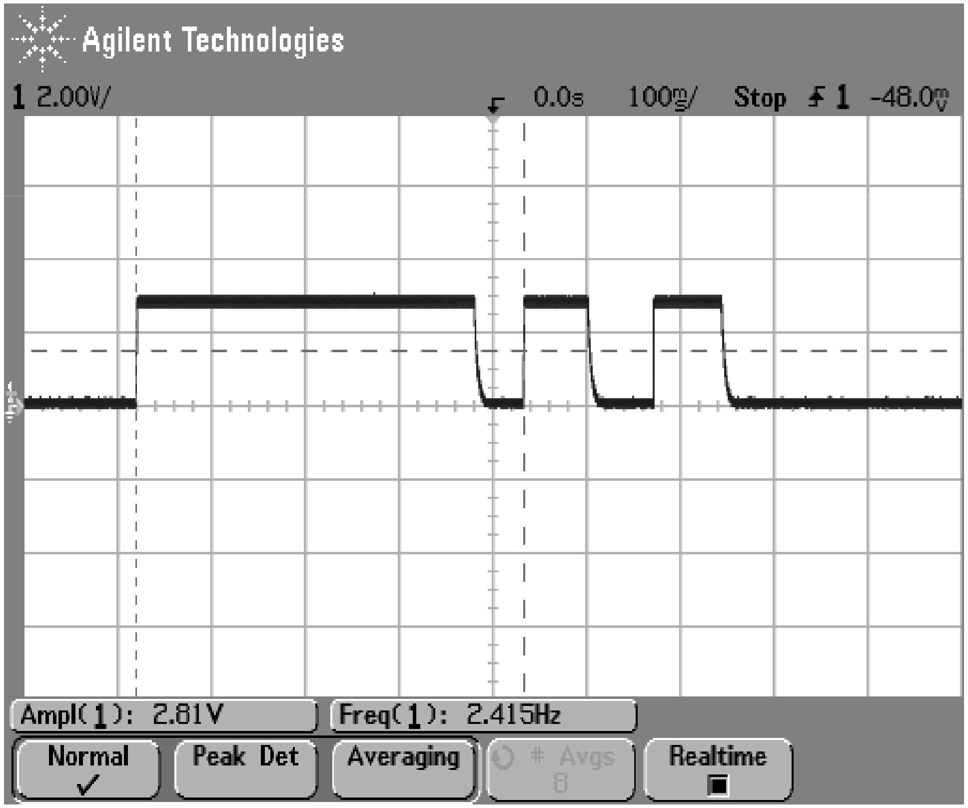




Motion Sensing Module

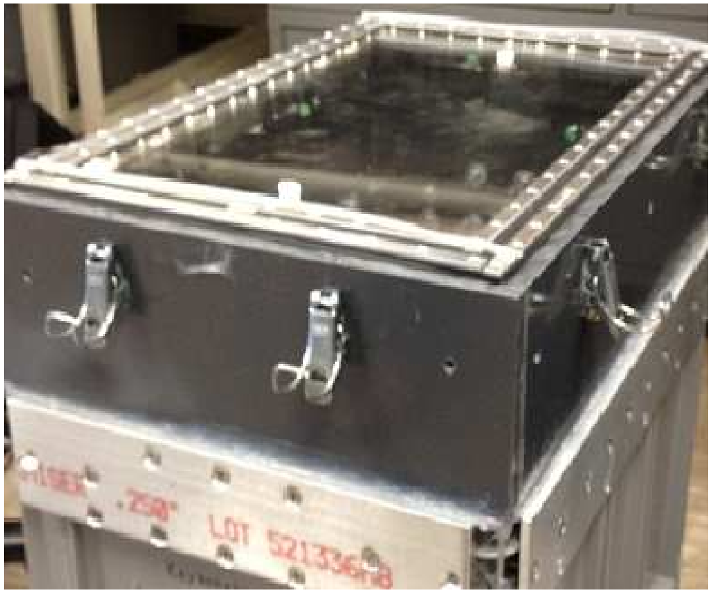
Testing and Measurements:

- The PIR sensors would generate 2.81V HIGH output when motion is detected.



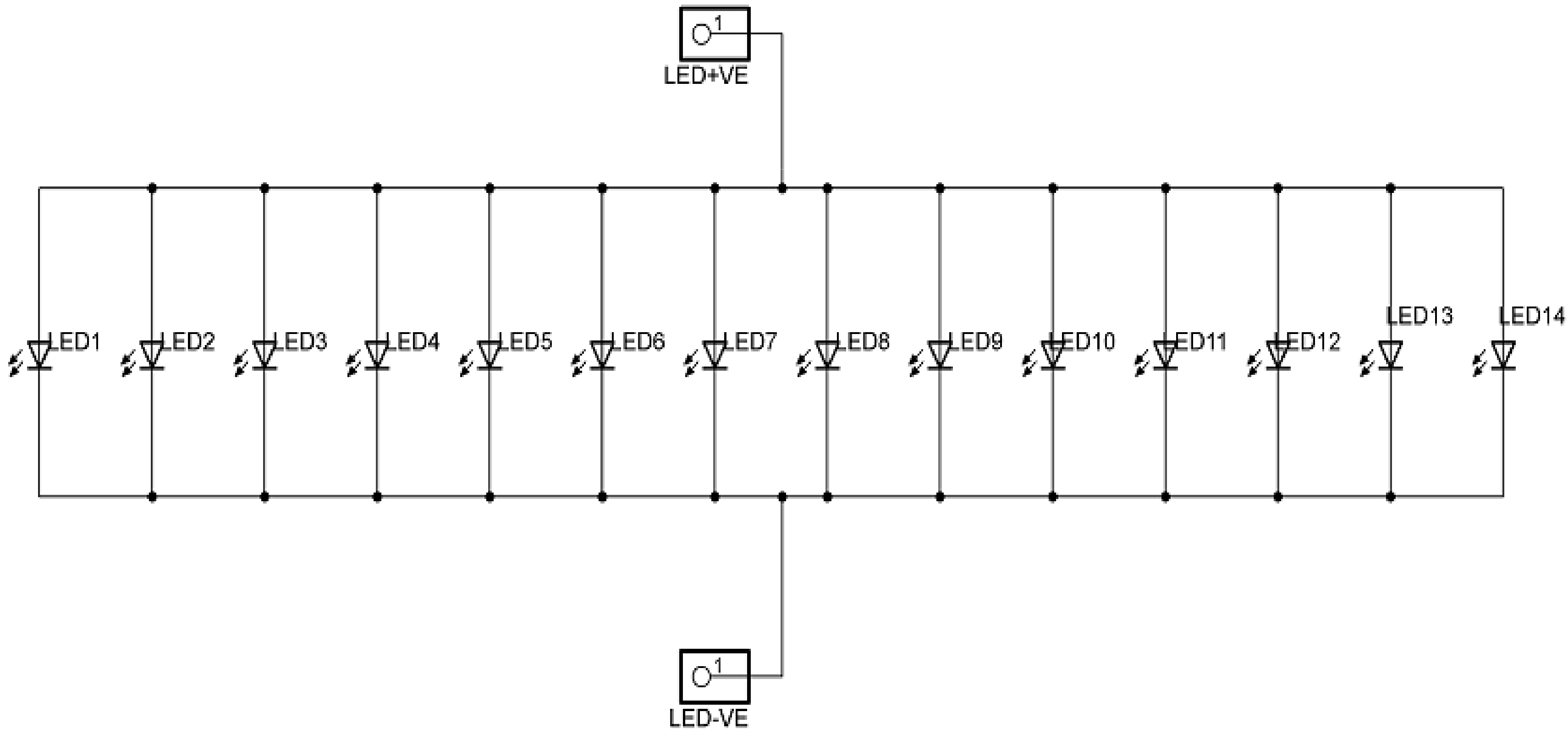
Lighting Module

- 14 surface mounted LEDs (Everlight Electronics 61-238/QK2C-B28322FAGB2/ET)
- Forward current of each LED = 60 mA
- Current in whole LED circuit = 60 mA x 14 = 0.84 A



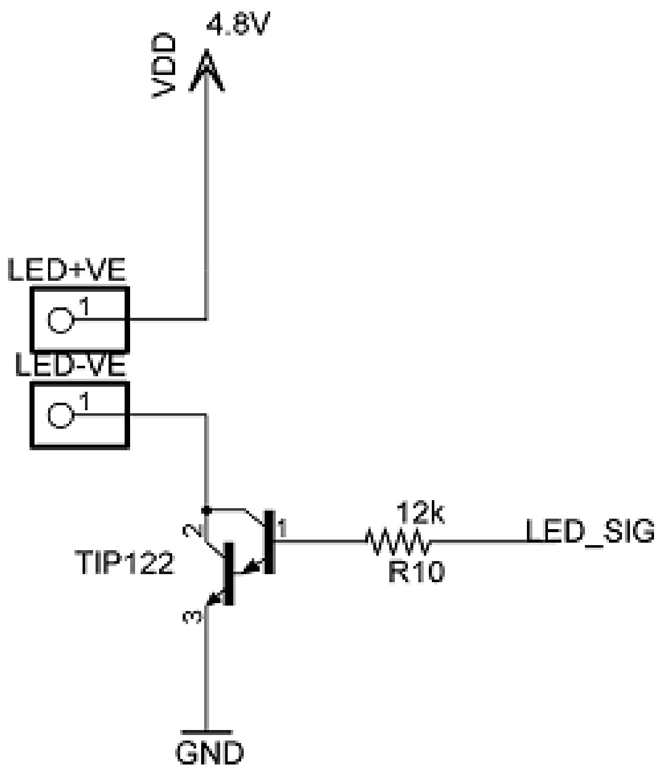
Lighting Module

Schematic of Lighting Module



Lighting Module

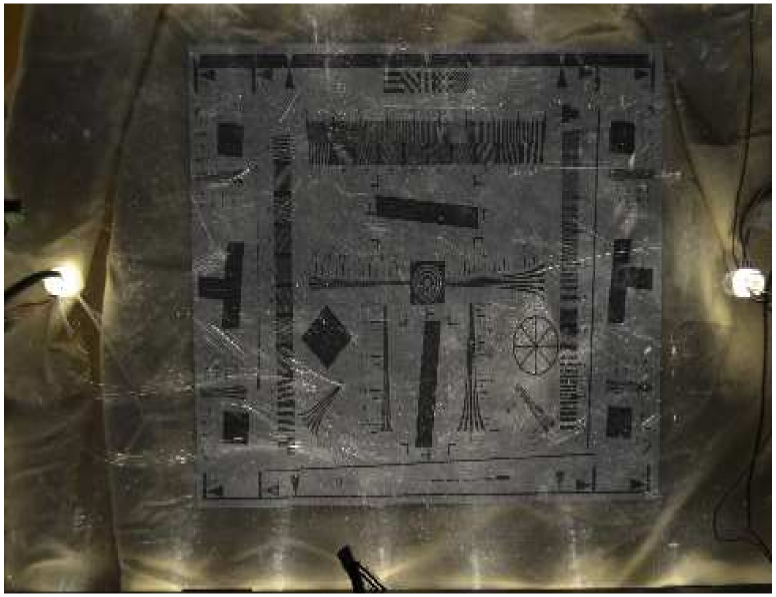
- Schematic of the switch (NPN transistor) of lighting module

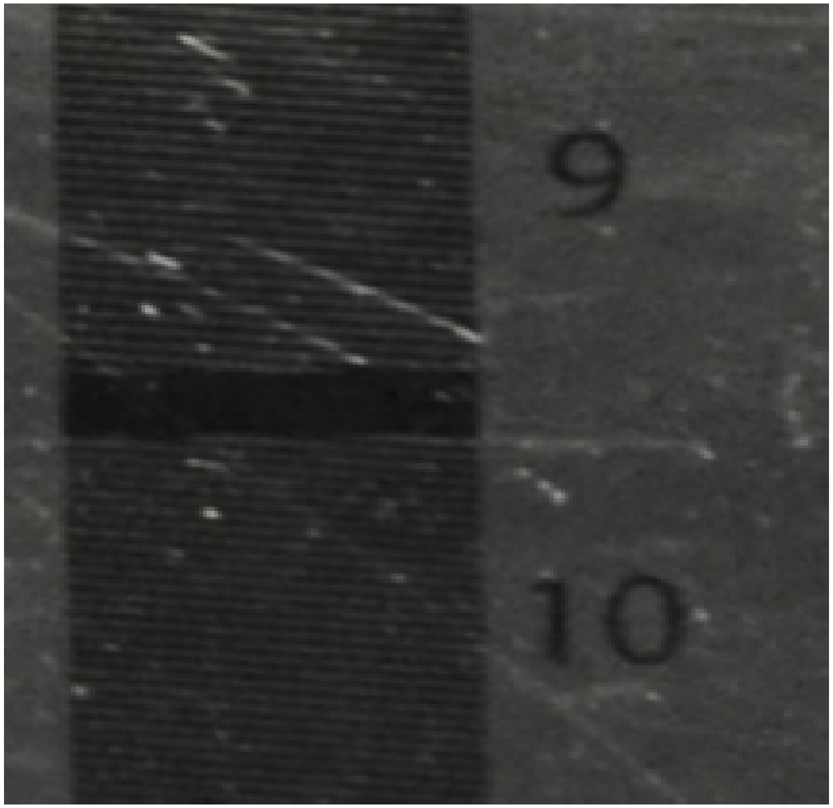


Situations	LED_SIG
When in standby	LOW
When activated by FSR	HIGH
When activated by PIR	Square waveform with increasing duty cycles from 0-80% within 4 seconds

Testing on Lighting Module

- To verify that the lighting unit can generate sufficient lights for high-detail images
- Results:





Power Supply Unit

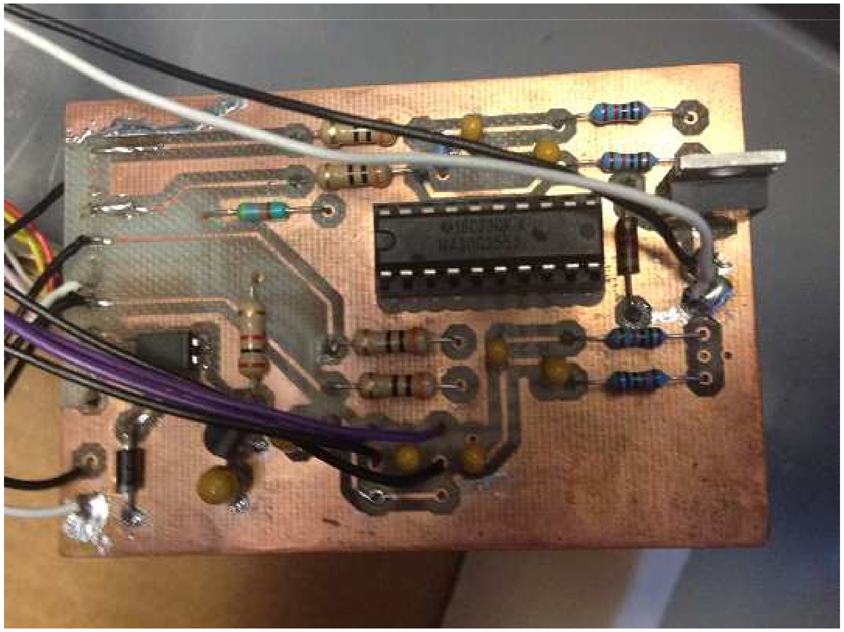
VDD(4.8V)

- Four Sanyo Eneloop AA NiMH rechargeable batteries (2000mAh) in series
- Input voltage of voltage regulator and lighting module

Power Supply Unit

VCC (3.0V)

- Microchip Technology MCP 1700 LDO 3.0V output voltage regulator
- Input voltage of control unit and the sensing modules



Testing on Power Unit

- To verify that the power unit is able to sustain device usage up to four days
- Results:

Situations	Device current Usage
When in standby	3.08 mA
When activated with PIR sensors	0.5 A

Standby current (4 days):
3.08 mA x 4 days x 24 hours/day = 296 mAh
Active current (4 days):
0.5 A x 5 seconds x 660 shots x 1 hour/3600seconds = 458 mAh

Total power consumed = 296 mAh + 458 mAh = 754 mAh

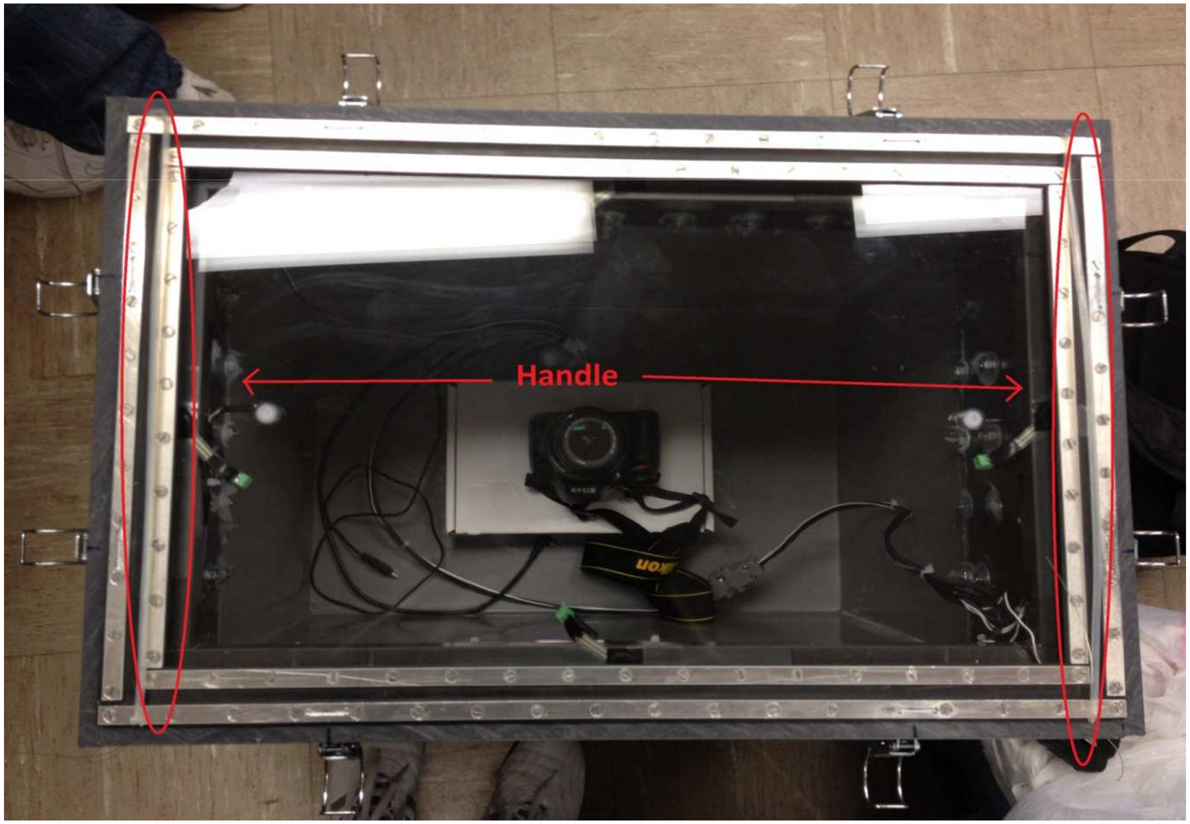
Container and Lid

Dimension:

Length (23”) ×
Width (15.5”) ×
Depth (21.5”)

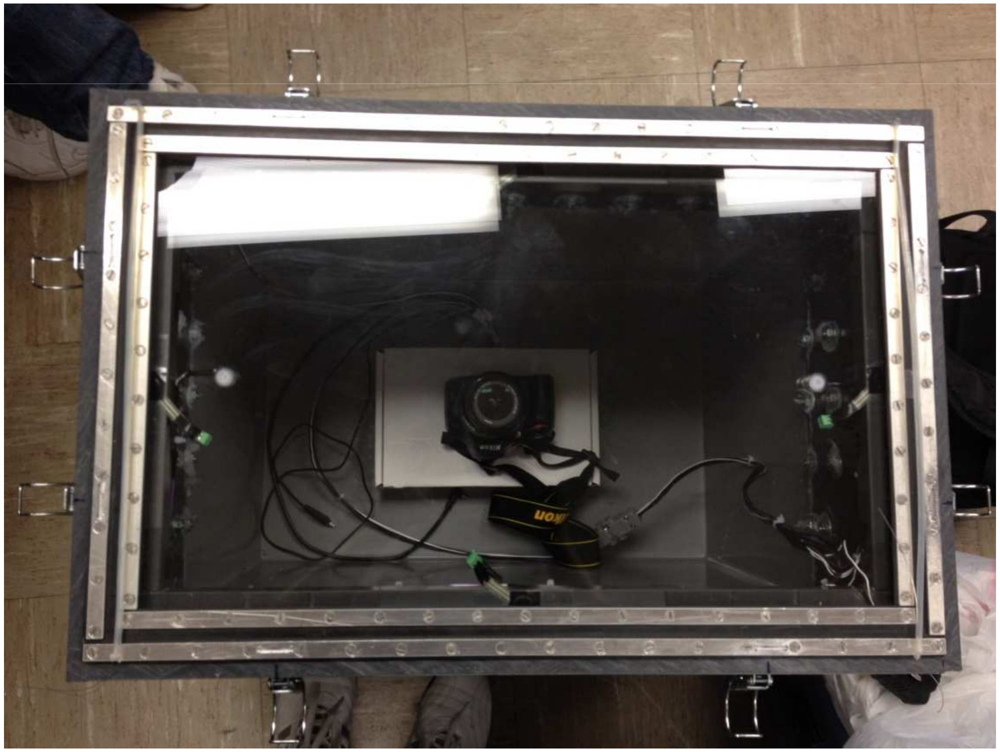
Container and Lid

Handles to take off the lid



Container and Lid

Gasket: Enable weight to be transferred to the FSRs



Container and Lid

Wiring (11Wires) :
Shared VCC (1)
FSR (5)
PIR (4)
LEDs (2)

15 pin D sub

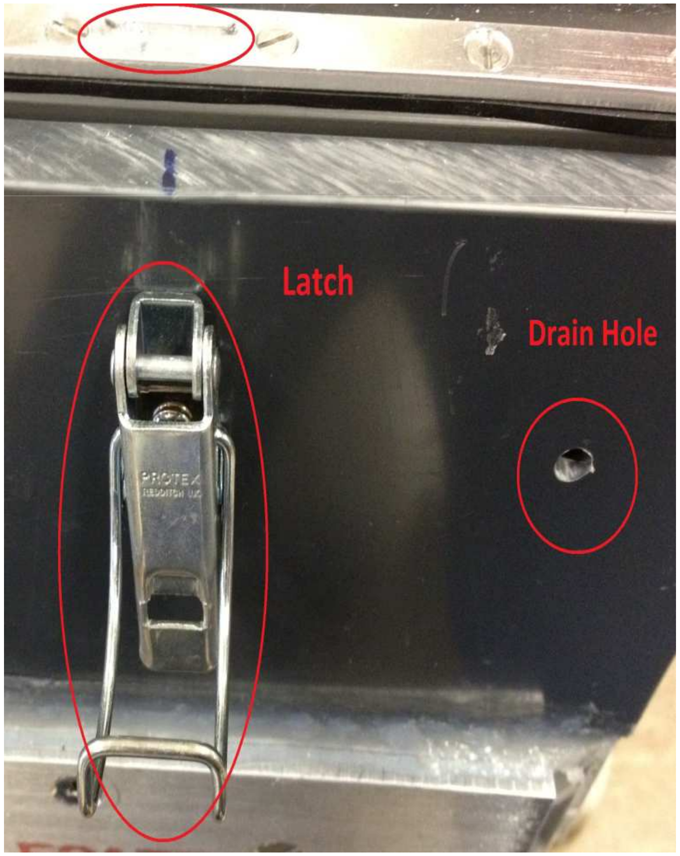
Design Challenges

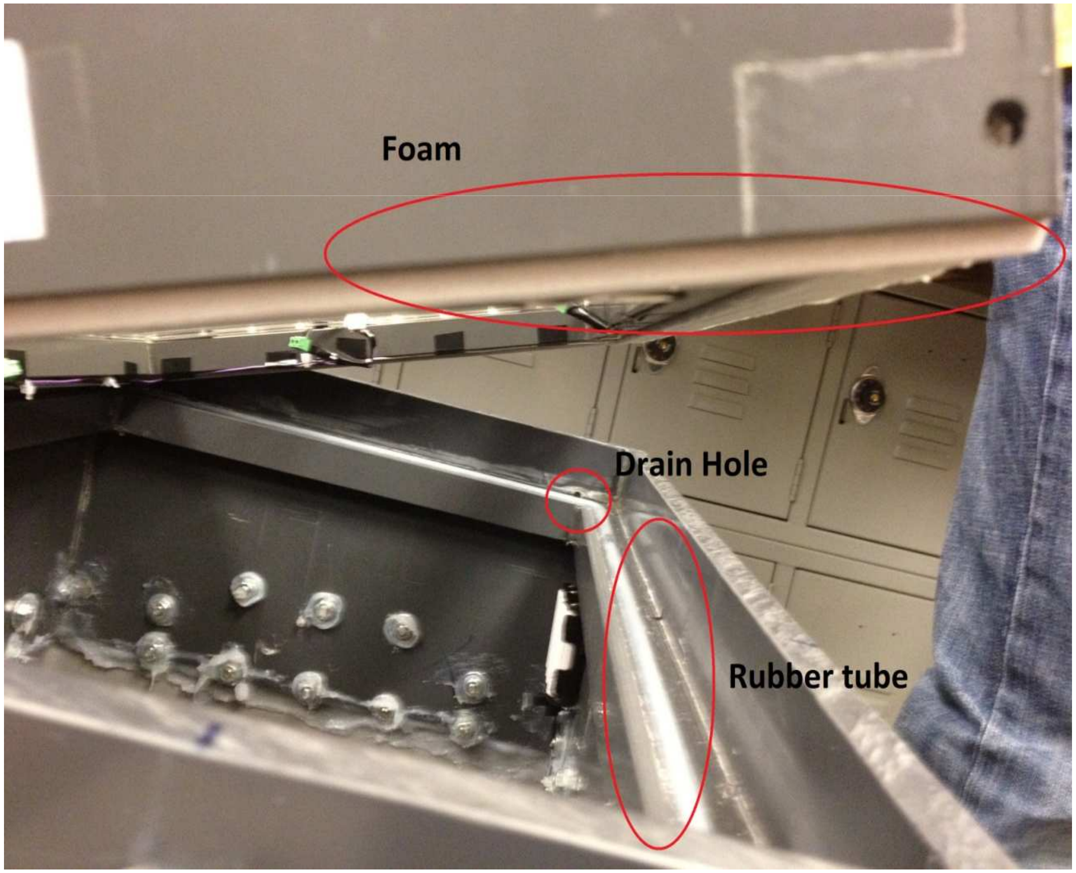
- Problem: Container will be placed outdoor at all times.

- Initial solution:
  - Use rubber tube and latch so that container is water-proof.
- Solution:
  - Add foam under the lid to make the seal tighter.
  - Drill drain holes around the lid to drain out the water.

Container and Lid

Amenities to make the container water-proof





Container and Lid

Testing: The container is water-proof

Other Tests

Frustrated Total Internal Reflection:

- acceptance angle for acrylic sheet to act as a waveguide

$$Acceptance\ angle, \theta_A \leq 2\sin^{-1}\sqrt{{n_{acrylic}}^2 - {n_{air}}^2} = 2\sin^{-1}\sqrt{1.491^2 - 1^2}$$

$$\theta_A \leq 180°$$

Success

- Able to capture human fingerprint without external light source

Recommendations

- Cheaper camera
- Adaptive camera setting to handle all lighting conditions
- Better window material that refrain from scratches

Ethical Considerations

- **IEEE code of Ethics #3: "to be honest and realistic in stating claims or estimates based on available data"**
  - Fully credit the responsible party or organization for material that is not produced by us fulfils

Thank you

- Professor P. Scott Carney
- TA Tom Galvin
- ECE Machine Shop, Greggory L. Bennett
- ECE Electronic Shop
- Samantha and Team (Illinois Natural History Survey)

Questions?