

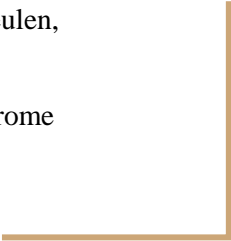


The Development of a Low Cost Pyranometer

Presented by the Solar Sailors

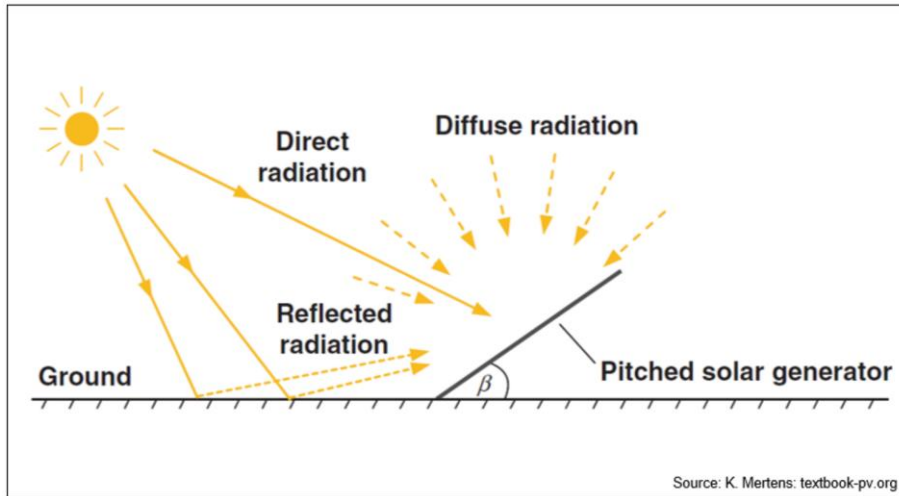
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Nickolas Borek , and Brady Jerome



Background

Solar Irradiance: W/m^2



Value Proposition



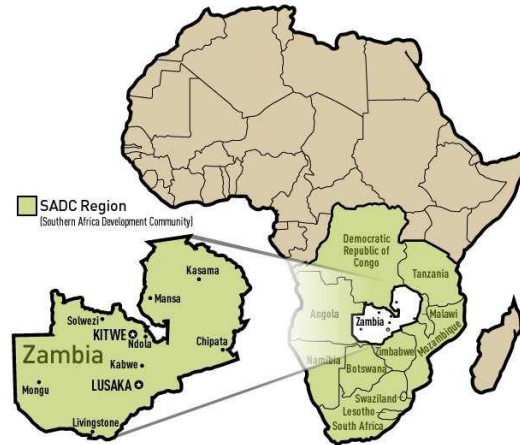
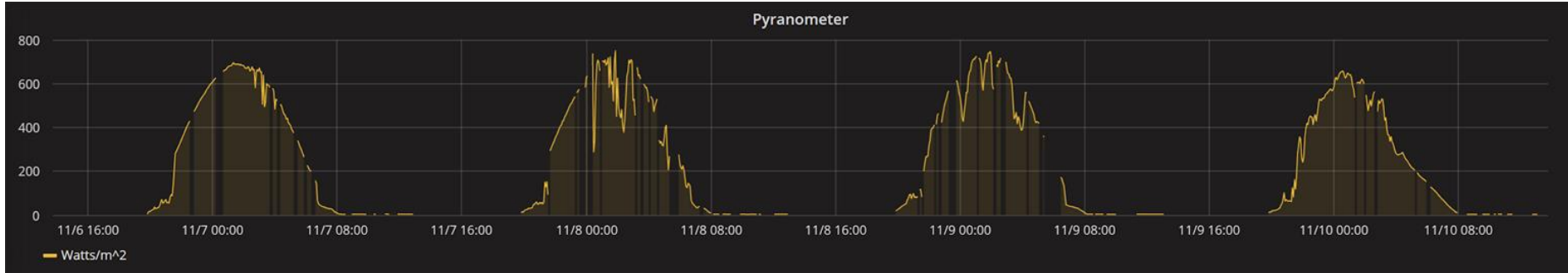
<http://kw4h.org/>



Community Needs

- Communication
- Information
- Refrigeration

Data from the Filibaba Zambia Station



Requirements

Commercial Pyranometer



Affordable

\$20-\$80

Accurate

- Provides a 0 - 5 VDC control signal
- < 15% error

User Friendly

- Easy to install and maintain
- Repeatable

Objective

Simple Design

- Fewer features
- Budget friendly
- Aim for accuracy



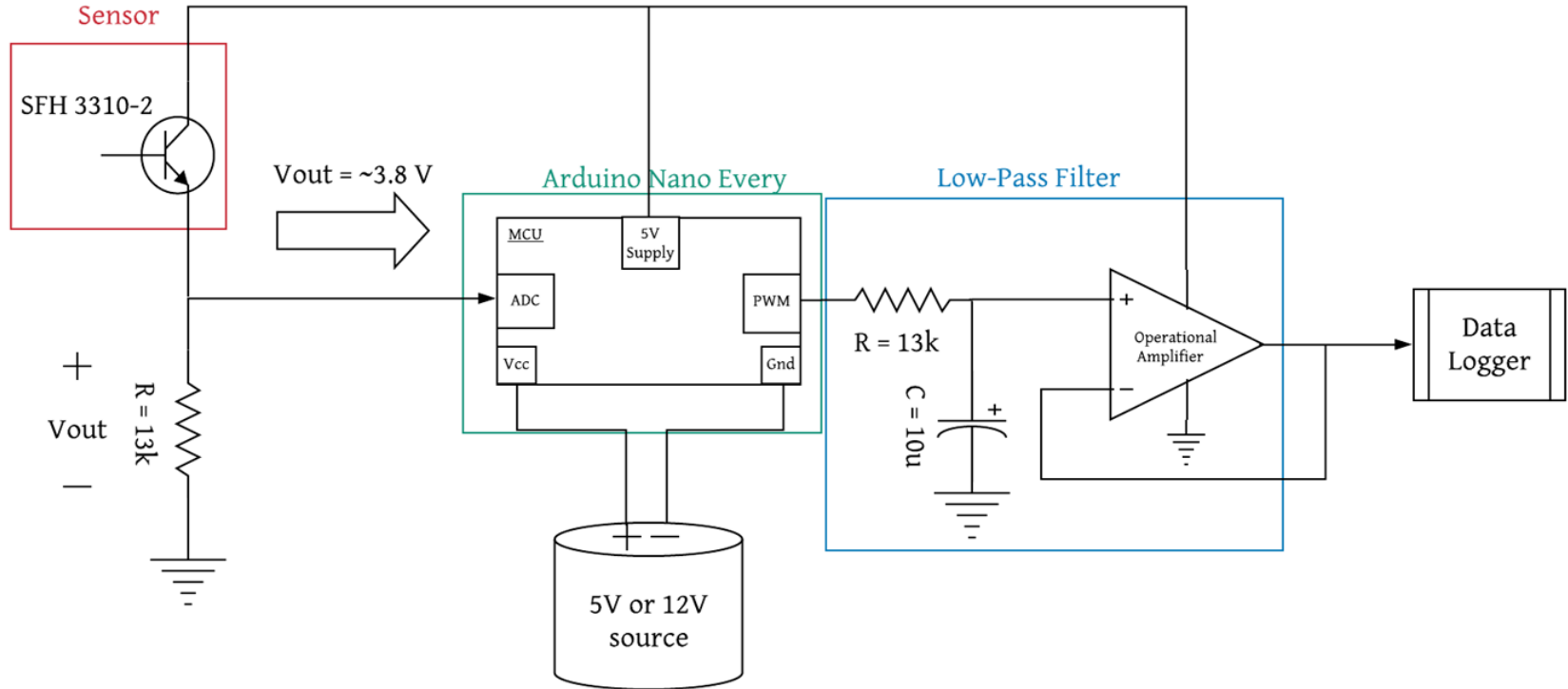
User Based

- Building Instructions
- Parts list



Meet our sponsor's requirements

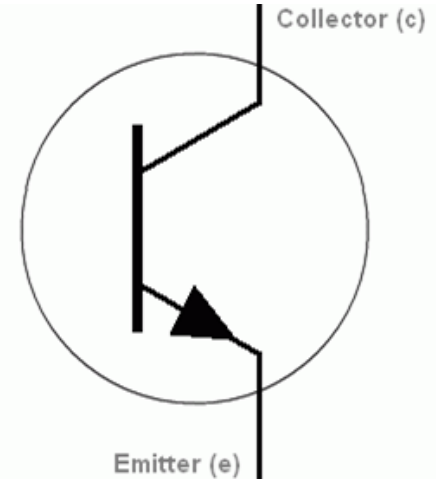
Conceptual Development: The Big Picture



Conceptual Development: The sensor

Phototransistor

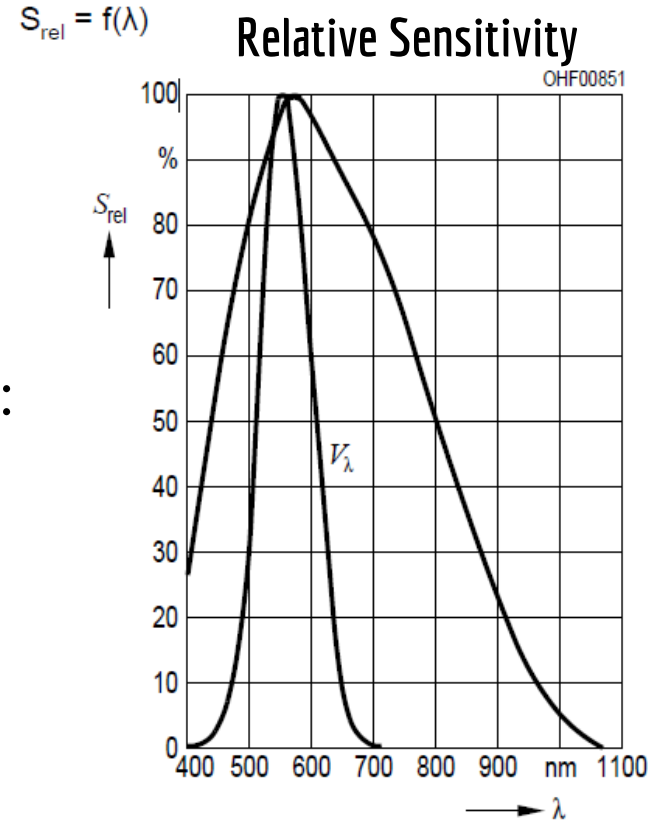
- Light Sensitive BJT
- Capable of turning light energy into electric energy
- Our sensor
 - SFH 3310
 - 150 degree viewing angle



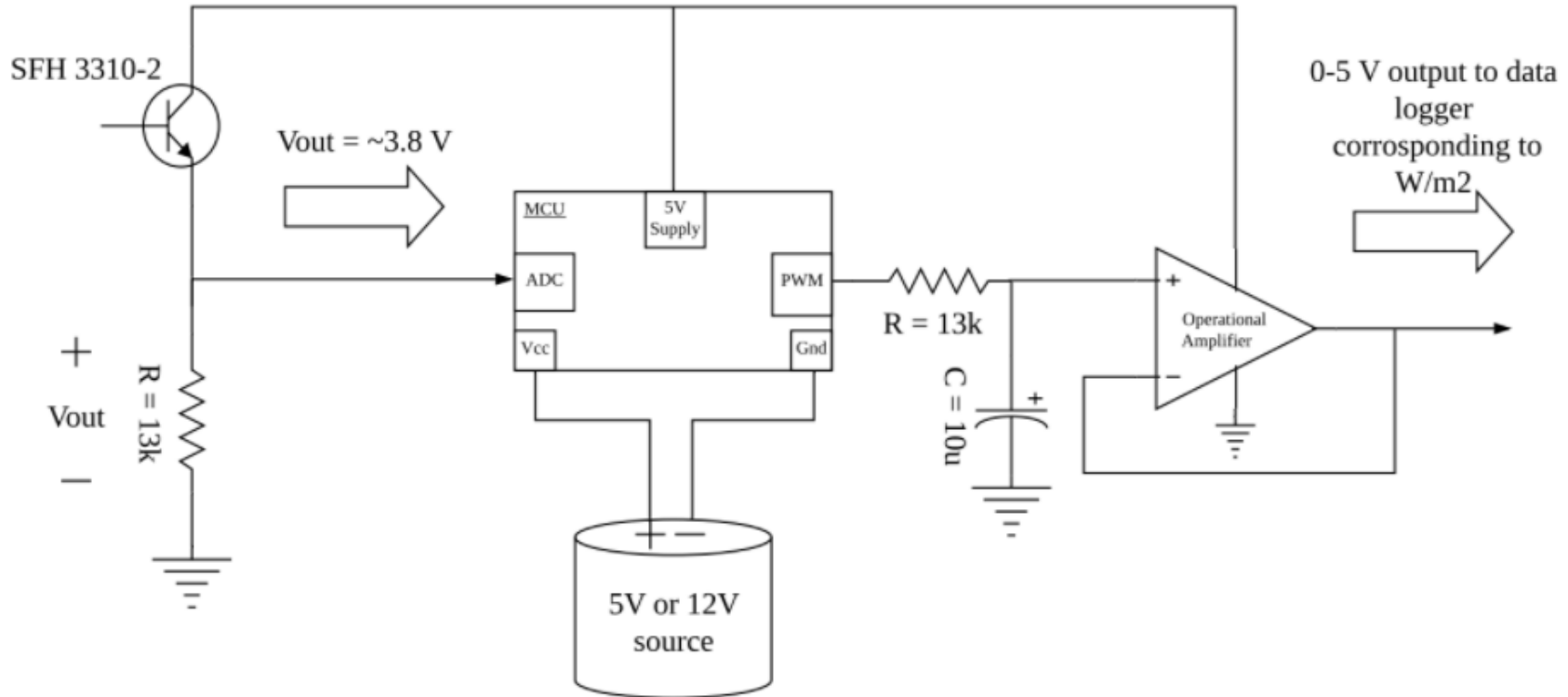
Conceptual Development: The sensor

- Why this sensor?

- Affordable: \$0.82 per unit
- 150 degree field of view
- Measures necessary light spectrum:
350 nm - 970 nm



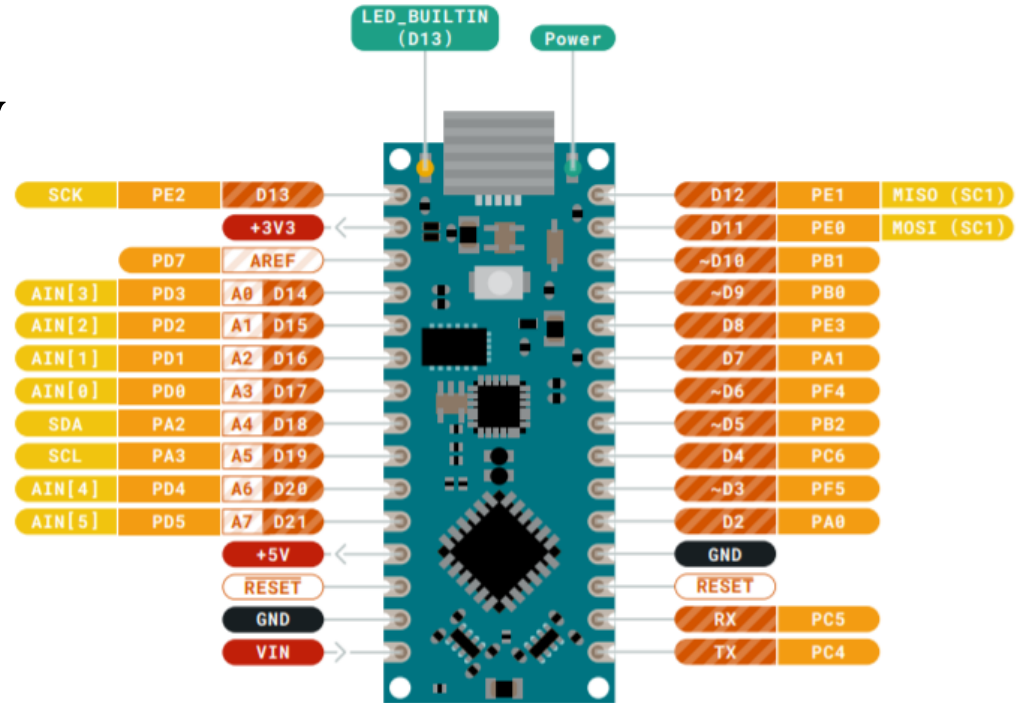
Conceptual Development: The Circuitry



Conceptual Development: The Microcontroller

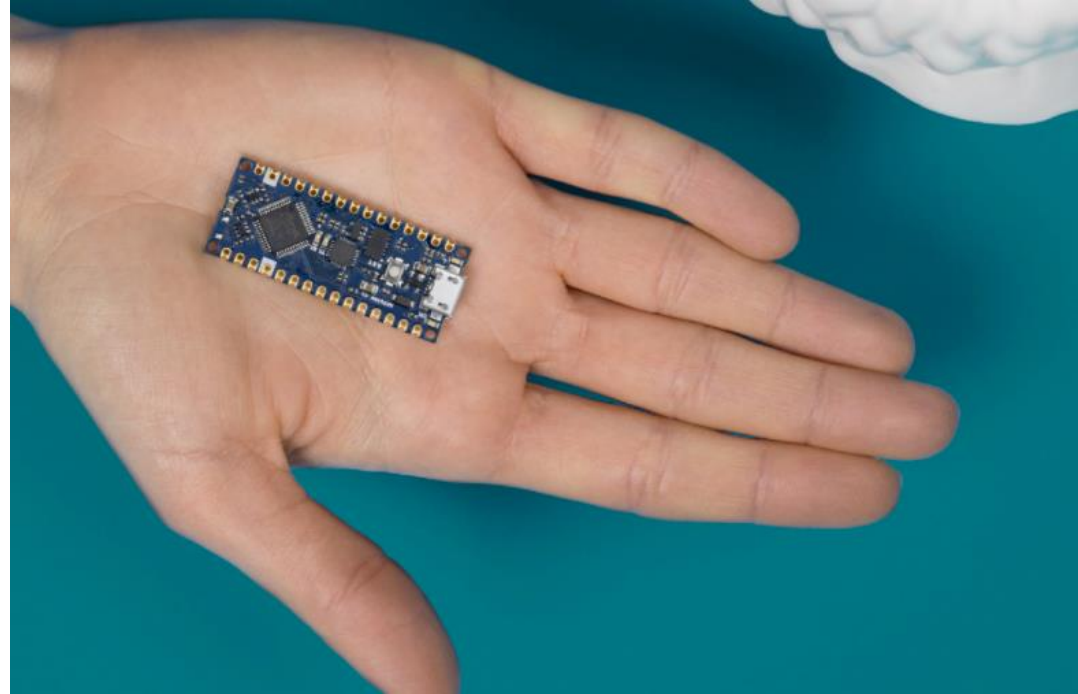
Arduino Nano Every

- Inputs: A0-A7
- Outputs: D3, D5, D6, D9, D10
 - Pulse Width Modulation (PWM)

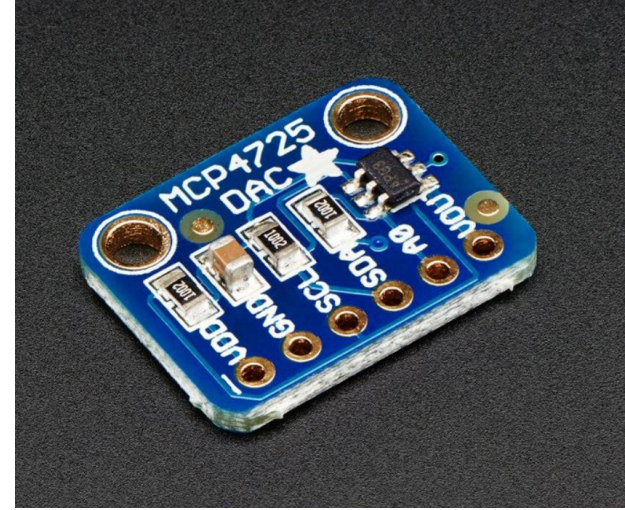
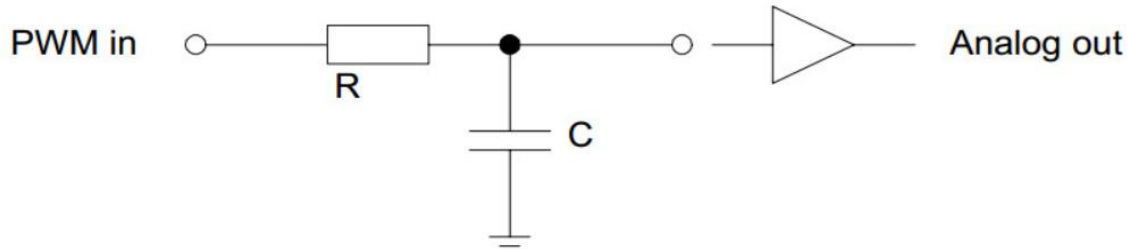


Conceptual Development: Why the Nano Every?

- Affordable: \$9.30
- Easy to implement:
 - Forums
 - Instruction manuals
 - Arduino IDE
- Compact: 15mm x 45 mm
- Excellent customer support



Conceptual Development: PWM vs DAC



	PWM	DAC
Cost (One Unit, without shipping)	\$1.13	\$4.95
Accuracy	99.8% Depends on R and C values.	99.9 %
Response Time	700 ms Depends on R and C values.	1 ms
Footprint	3.05mm x 10mm	33mm x 33mm
Implementation	Direct connection	I2C communication

Material Selection 3D Printing (ABS vs PETG)

ABS

- Higher temperature
- Strength characteristics
- Cheaper
- Toxic

Recommendation: use ABS when cost is a significant concern and you have the proper printing setup.

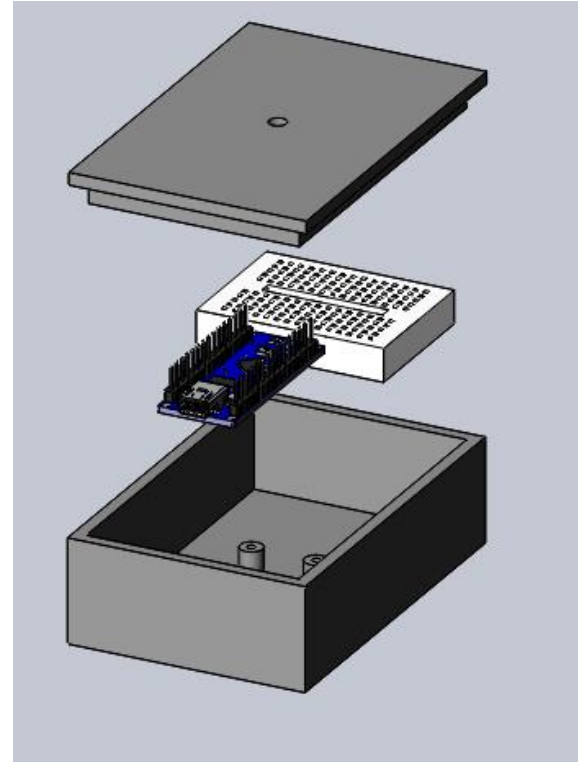
PETG

- Solar resistance
- More expensive.
- Intermediate print difficulty

Recommendation: use PETG when economically and structurally possible since its UV resistance makes up for its downsides.

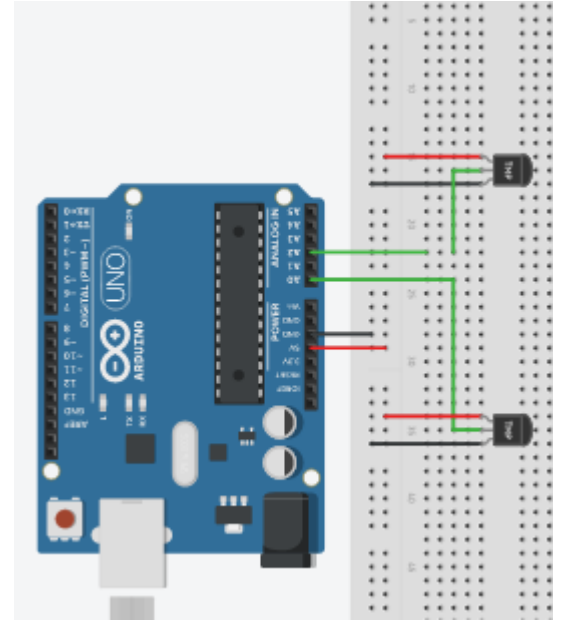
Conceptual Development: The Case

- 3D printed made of PETG
- Currently relies on a snap fitting with plans to update to use fasteners.
- Plans on keeping particles larger than 1mm out and be water resistant.



Thermistor Prototype Reasoning

- Serves as a cross competitor with our phototransistor design
- Widens our view of potential solutions for our project
- Does not affect our teams budget

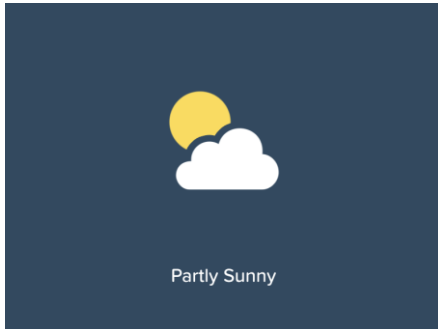


Recommendations: Moving Forward

- Use the phototransistor prototype.
- Use PWM to output to data logger.
- Implement the circuitry and case previously shown.
- Test our product against industry grade products.
 - Three comparable products



Identification: Potential Risks



- Environmental Issues
 - Weather-proof exterior, and protected components
- Product Failure
 - Perform many product tests to ensure a working device and test life-span
- Sensor Drift
 - Properly calibrate the sensor
- Improper Soldering
 - Look into an interlocking PCB
- User Error
 - Create a durable and impact-reducing case

Validation: Testing

- Test circuit for desired output
 - Is it outputting 0-5V?
- Test and calibrate phototransistor
 - Is it working properly?
- Test phototransistor pyranometer prototype
 - Compare with other pyranometers
- Re-evaluate prototype design
 - Did it work properly?
 - Is this the best design?
- Test the thermistor prototype
 - To make an accurate phototransistor choice
- Test case and circuitry in Environment Chamber
 - Does it meet environment requirements?



MP-100: Pyranometer Integral
Sensor
\$361.00



SP-215-SS: AMPLIFIED 0-5 VOLT
PYRANOMETER
\$273.00



CMP10 Pyranometer
Provided by the University of Idaho

Cost per unit

Current Cost Per Unit

Item	Total Cost	Quantity	Cost for 1
10 uF Capacitors (50 count)	\$ 4.92	50	\$ 0.10
Resistors (600 count)	\$ 4.99	600	\$ 0.05
Arduino Nano Every (6 count)	\$ 55.80	6	\$ 9.30
Arduino Nano Every Headers (400 count)	\$ 4.99	13	\$ 0.38
3D printing filament (1 count)	\$ 22.99	1	\$ 3.83
Op Amp NJM5532DD (10 count)	\$ 10.50	10	\$ 1.05
Photo Transistor SFH 3310 (10 count)	\$ 8.57	10	\$ 0.86
	Current Cost Per Unit		
	\$		15.57

Recommendation: Future Ideas

- Convert 0-5V voltage output to 0-20mA current output.
 - Eliminates voltage drop over a distance.
- Research and test the viability of a two-sensors system.
- PCB vs Breadboard



Any Questions?