Solar Clean Water Device

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Background

"Failure to provide safe drinking water to all people is perhaps the greatest development failure of the 20^{th} century"[1]

Figure 1: Man drinking turbid water

Problem Definition

- It's estimated that as many as 135 million people will die from the diseases caused by waterborne contaminations by 2020[1]

- 1.1 billion people lack access to improved drinking water supply[2]

Figure 2: Boy drinking available water

Refined Problem Definition

- There is no technology that can filter turbid water for people and communities in developing areas
- Develop an automated device in contrast to BioSand Filters ; which is the most commonly used method of filtering turbidity in developing areas

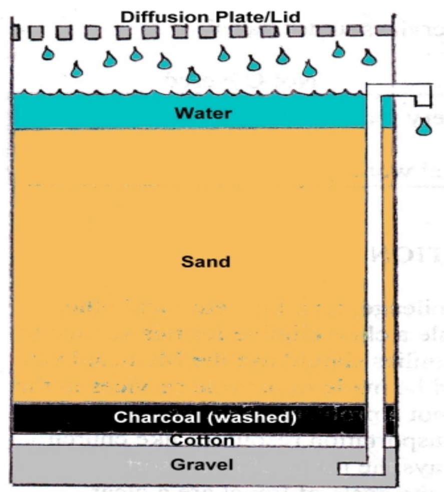


Figure 3: BioSand Filter

Major drawbacks of BioSand Filters:

1. Time
   a. 30-40 minutes per cycle
2. Produces less than 4 L of water/day
3. Take one month for the filter to reach full efficiency

What is Turbidity and why filter it?

Figure 4: River highly contaminated with turbid water

Turbidity is Muddiness created by stirring up sediment of having foreign particles suspended

Indicates possible sources of microbial contamination and should be minimized as much as possible[6]

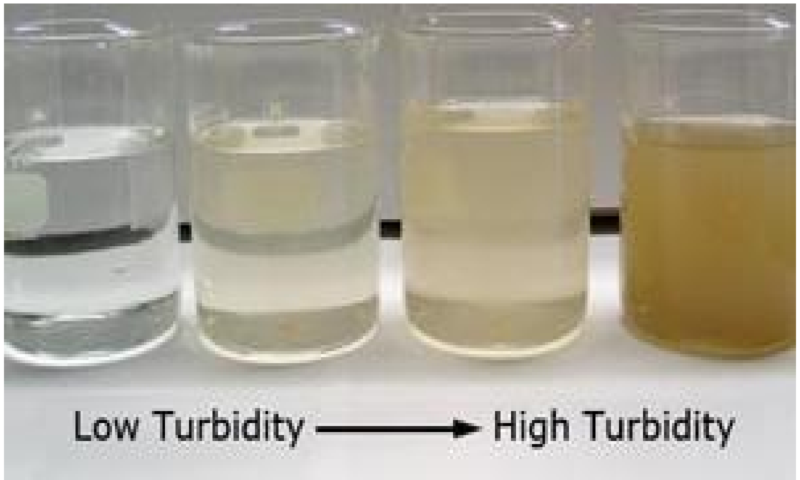


Figure 5: Different levels of Turbidity

Design Requirements

Function	Requirement
Power (Photovoltaic Cells)	•Components total output voltage and current levels satisfy the I-V curve of the Photovoltaic Cell
Control	•Toggle Switch controls when power is distributed
Detection	•Sensor detects Turbidity Levels>5Nephelometric Turbidity Units (NTU) Values
Time	•Completes one cycle in <10 minutes
Data Processing (Intel Atom Processor & Arduino Microcontroller)	•Solenoid Valve •Water Pump •Sensor Values •Battery Life •Cycle Status

Current Status of Art

To our knowledge this is the first case of an automated clean water system implementing photovoltaic power generation for developing areas

Solution Approach

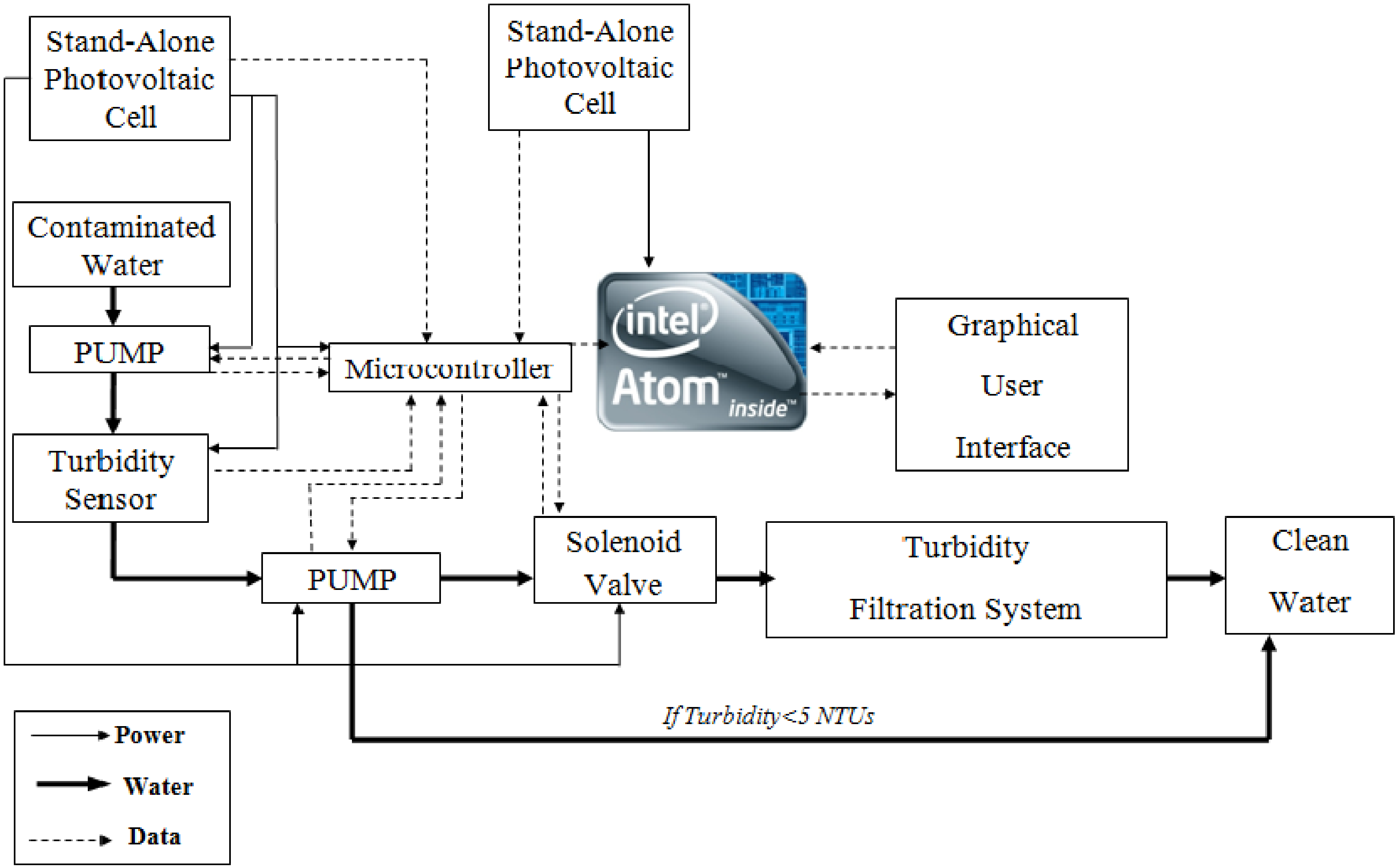
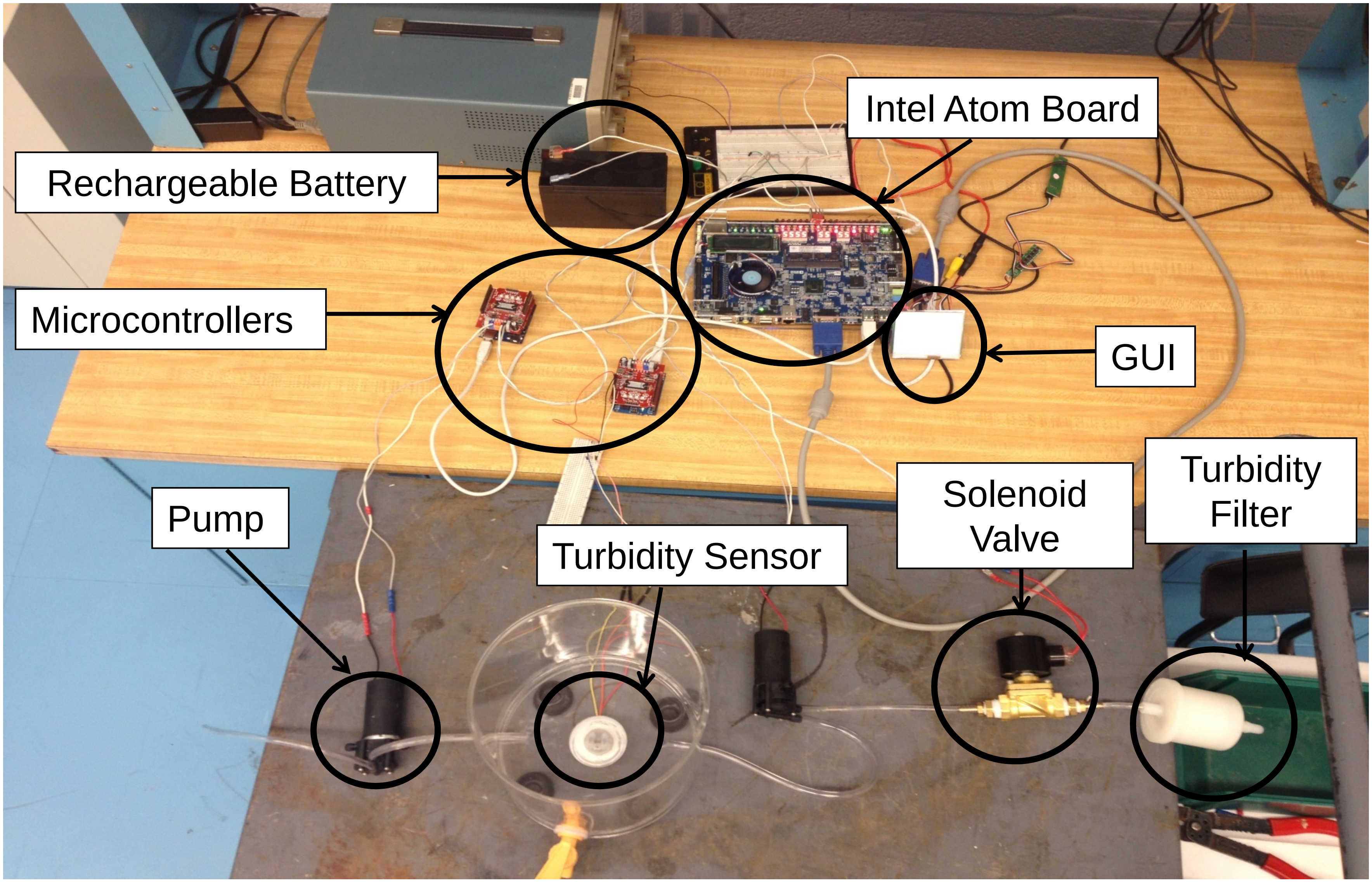
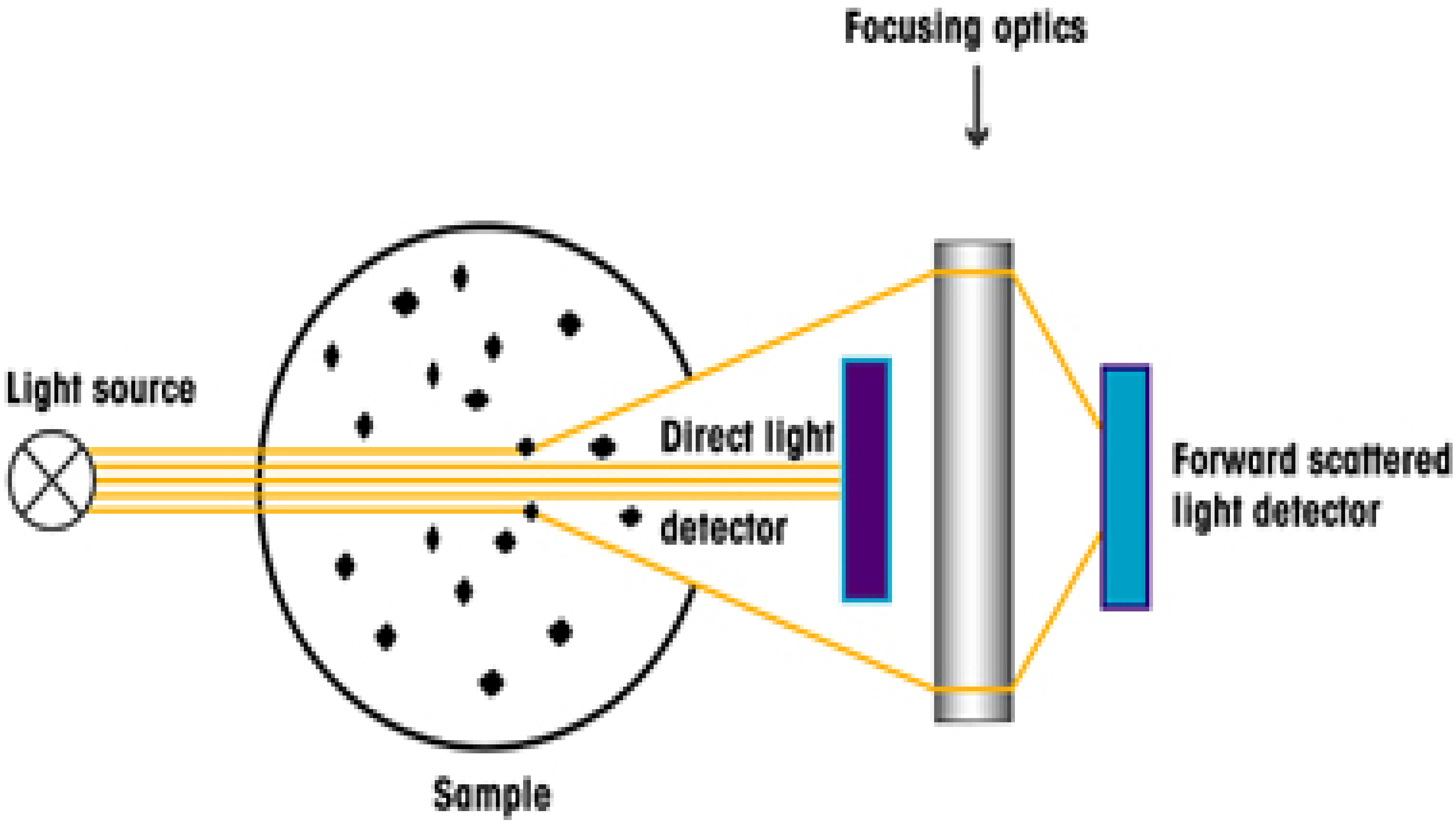


Figure 8: Solar Clean Water Device Flow diagram

Solution Approach



Turbidity Sensor (Concept)



Implementation

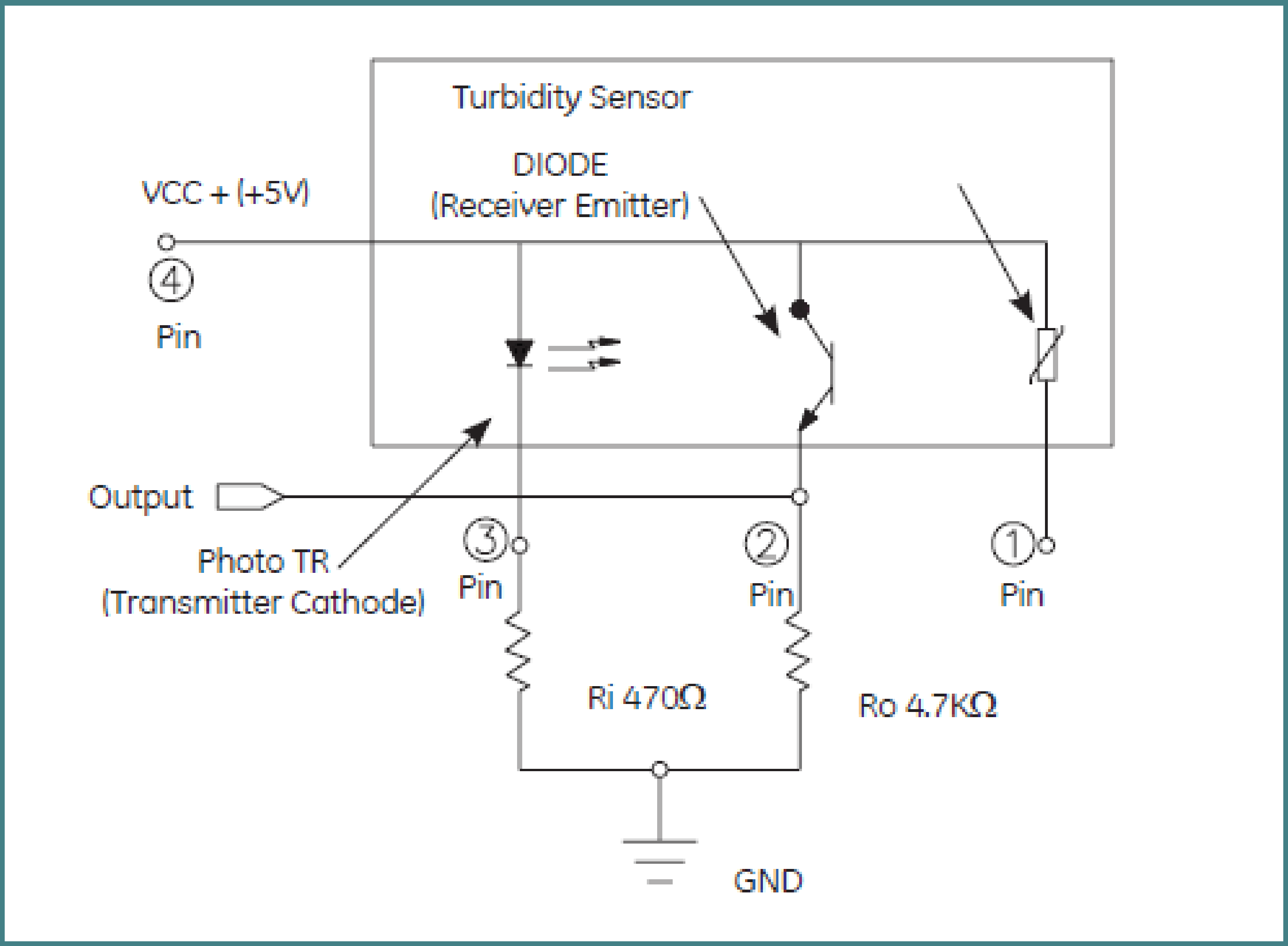


Figure 9: Turbidity Sensor Circuit

Implementation

Figure 10: Turbidity Sensors

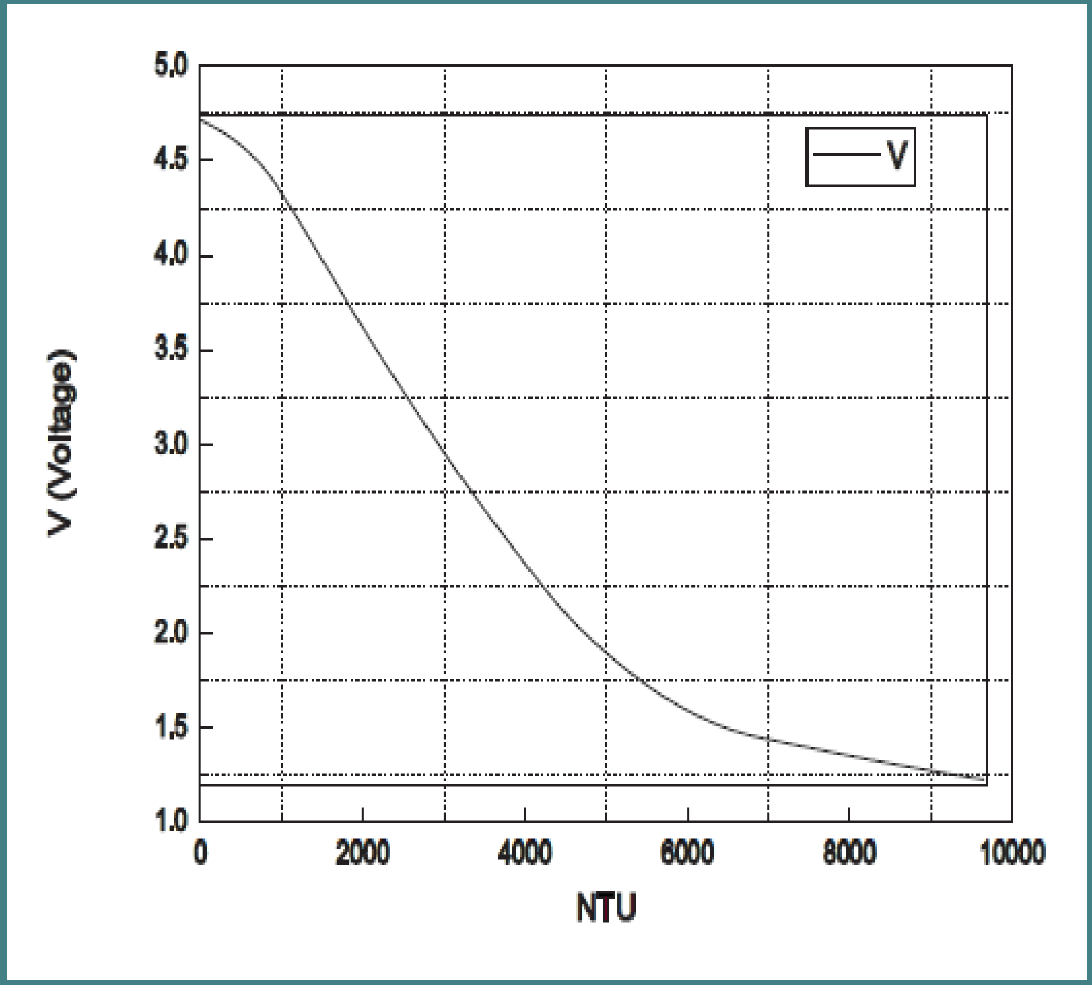


Figure 11: Voltage-to-NTU Conversion

Testing & Evaluation: Turbidity Sensor

Evaluated the turbidity sensor to define a distinguishing value between pure water and lightly turbid water

Trail #	Sensor Reading
Trial 1	5.00
Trial 2	4.99
Trial 3	4.98
Trial *N*	x.xx

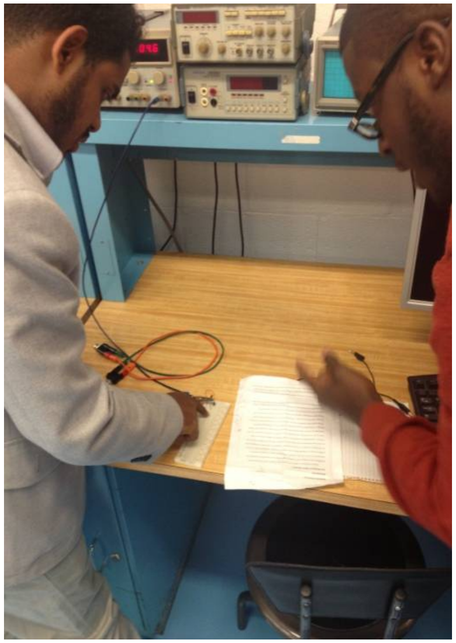


Figure 12: Henok and Ade investigating the sensor concept

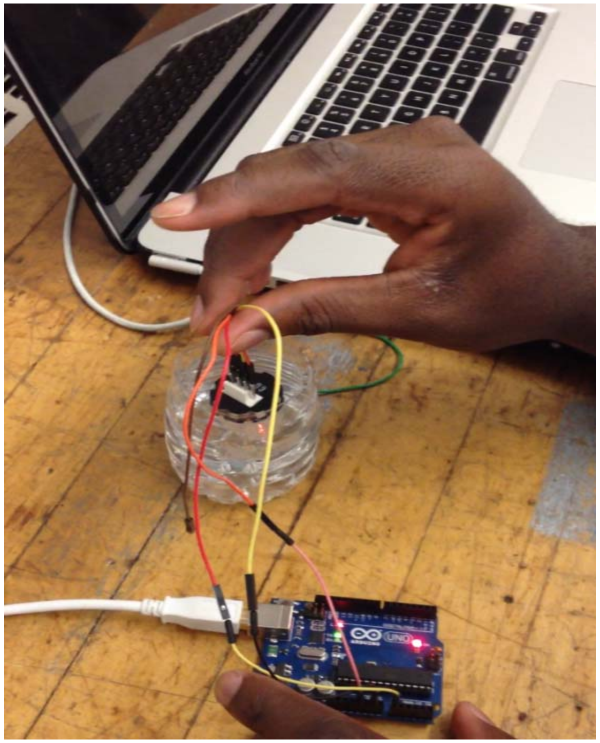


Figure 13: Turbidity Sensor Submerged in pure water

Power Analysis

Component	Voltages (Volts)	Current (Amps)	Power (Watts)	Hours of use per day	Watt – hours energy
Intel Atom board	12	7.5	90	4	360
Turbidity Sensor	5	.3	1.5	4	6
VGA/LCD Screen	12	.3	3.6	4	14.4
Arduino	5	.09	.45	4	1.8
Solenoid Valve	12	.5	6	4	24
Pump	6	.8	4.8	4	19.2
Total		9.49	106.35	425.4	

Power Analysis

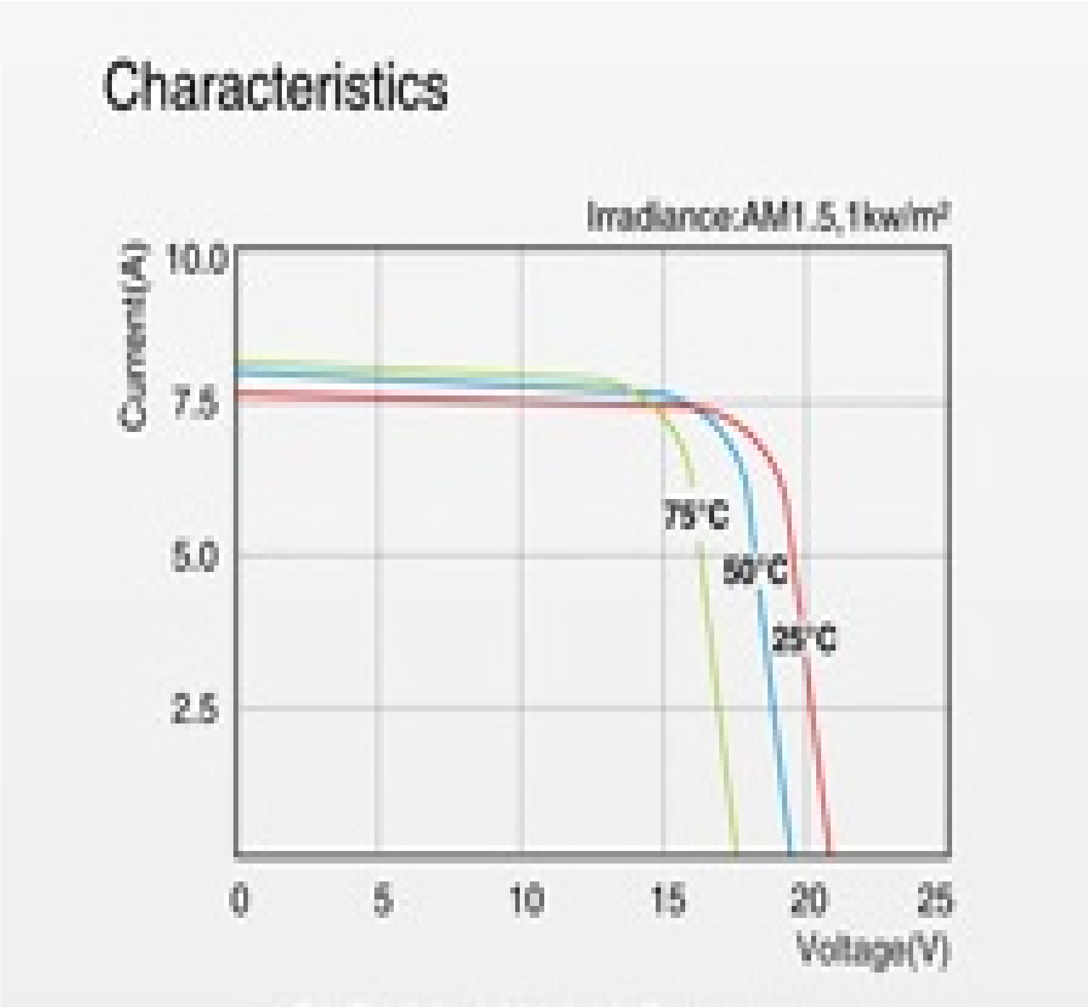


Figure 14: I-V Curve of 12V 120 Solar Panel

Providing Solar Energy by PV cell is not feasible

- I_{sc} = 7.72A
- V_{oc} = 21.6V
- V_{MAX} = 11.21V
- I_{MAX} = 6.98A

- Recall,

I_{out} = 9.49A
V_{out} = 106.35

Total output current of the device exceeds Short – Circuit current

Power Analysis

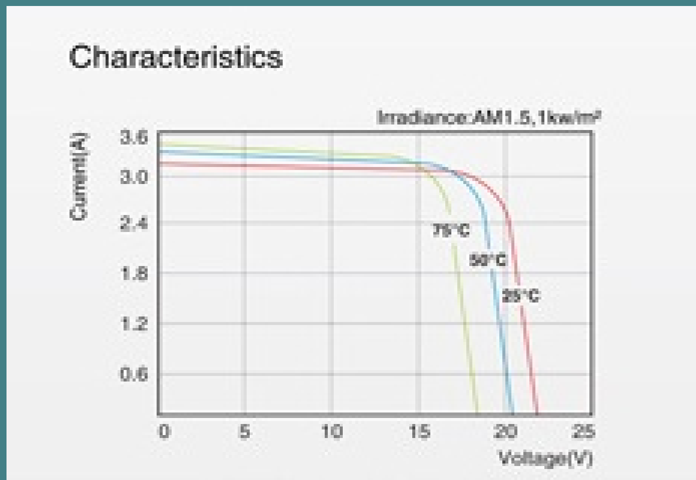


Figure 15: I – V Curve of 12V 50W Solar Panel

- I_{sc} = 3.23A
- V_{oc} = 21.6V
- V_{MAX} = 17.2V at (P_{MAX} = 50W)
- I_{MAX} = 2.91A at (P_{MAX} = 50W)

- Components excluding Atom:

I_{out} = 2A
V_{out} = 16.35W

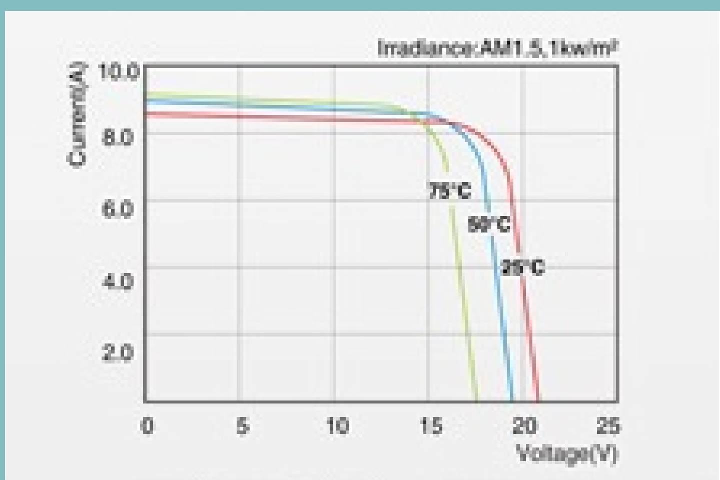


Figure 16: I – V Curve of 12V 130W Solar Panel

- I_{sc} = 8.36A
- V_{oc} = 21.6V
- V_{MAX} = 17.2V at (P_{MAX} = 130W)
- I_{MAX} = 7.56A at (P_{MAX} = 130W)

- Intel Atom Board

I_{out} = 7.5A
V_{out} = 90W

Cost and Resources

COMPONENT	MANUFACTURER	TOTAL COST
Turbidity Sensors	General Electronics (TSW-10)	$32.21
VGA/LCD Screen	AEI	$196.47
Direct-Current (DC) Water pump x 2	Trossen Robotics	$57.89
Turbidity Filtration System	Waterra	$27.08
Solenoid Valve	EHCOTECH	$32.72
Solar Panel Mounting Brackets	Unlimited Solar, INC	$45.98
50 W 12 V Polycrystalline Silicon Photovoltaic Solar Cells	Unlimited Solar, INC	$115.00
130W 12 V Polycrystalline Silicon Photovoltaic Solar Cells	Unlimited Solar, INC	$219.00
TOTAL		**$726.85**

Conclusion

- Successfully integrated the system and completed different test cases that satisfied certain design requirements

- *Further Work*:

  Integrate the device with the late solar panels then test and evaluate its performance before the Cornell Cup (May 3rd, 2013)

References

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Questions