AUTONOMOUS PHOTOVOLTAIC PANEL CLEANING SYSTEM

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Project Outline

1. Autonomously clean photovoltaic (PV) panels
   - Climbing up on the roof may be dangerous
   - Hiring a company could cost up to $1600 annually
2. Solution would not include the use of water
   - Ideal locations for PV panels are in areas with high sunshine & as a result, less water
3. System would have to determine when there is the need for self cleaning
   - Cannot rely simply on a reduction in voltage as this would be the case in the night and on a cloudy day
4. In the event of a malfunction, there should be a way of automatically shutting off the system

Project Need

- Airborne dust particles can reduce efficiency by up to 7% (U.S. Dept of Energy)
- Efficiency reduced by up to 30% when adding in falling leaves & water streaking
- $10,000 of lost value in its lifetime for residential
  - Significantly higher for a large scale Solar farm.

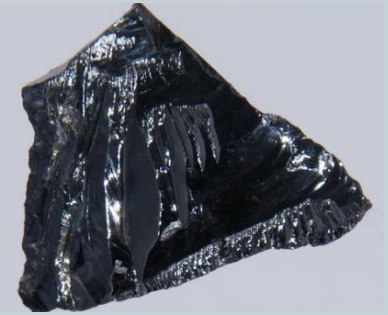
Project Motivation

- All members were interested in “green” technology
  - Hurricane Sandy left us all without power & revealed, even more, the significance of global warming
- Solar Decathlon 2013 Competition
  - Build a zero-energy emission home
  - Uses solar panels

- This is a real problem
  - Mars rover Curiosity was switched from Solar power to Nuclear power because of the dust storms on Mars

Solar Panels

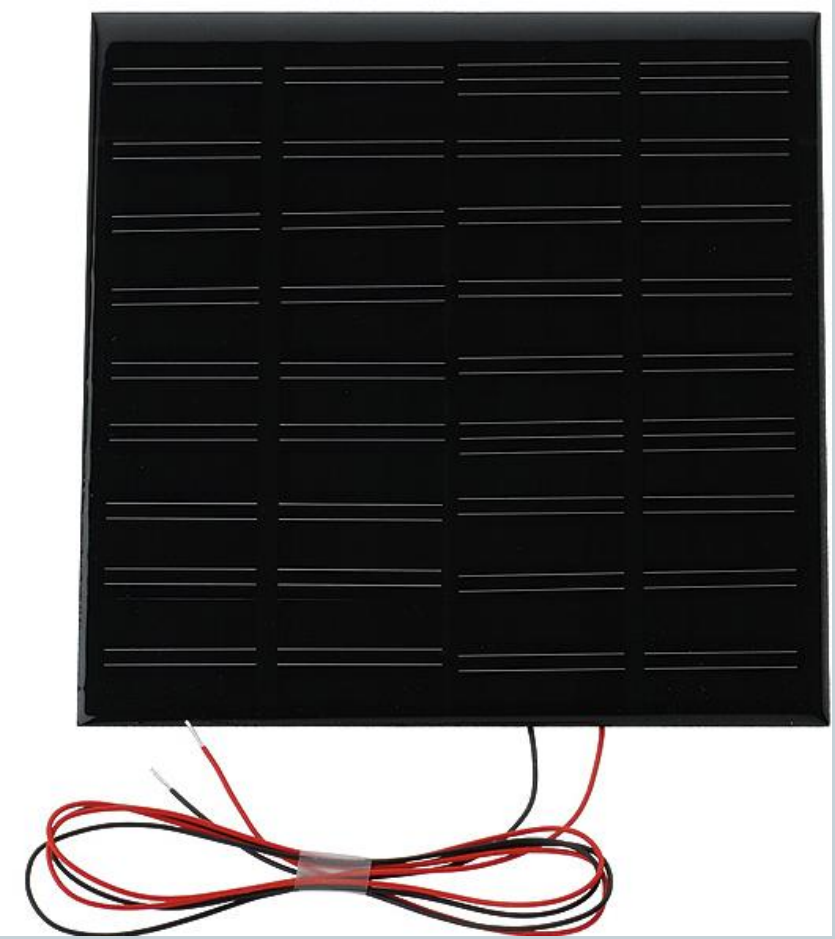
- Photovoltaic comes from *photo* for light and *voltaic* for electricity
- PV cells are made of semiconductor material, most commonly silicon
- Silicon is coated with an antireflective coating to reduce losses from photons bouncing away
- Finally, it is covered with a glass plate to protect it from the elements.



Solar Panel

- Specifications of interest:

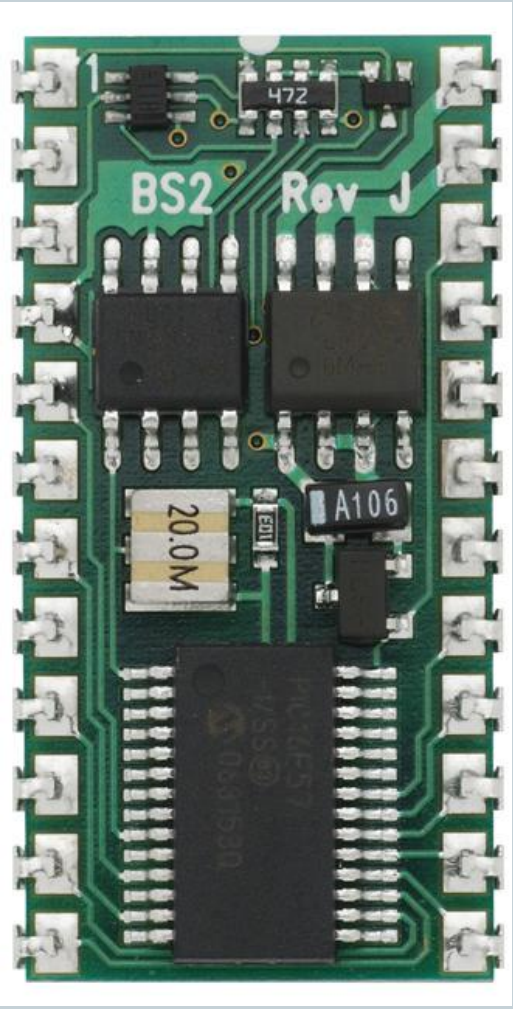
- 9 VDC Max Output
- Dimensions: 5.3 x 5.3 x 0.1 “ (135 x 135 x 2.8 mm)
- Operating temperature range: +32 to +158 °F (0 to + 70 °C)
- Already mounted positive and negative wires



Microcontroller: BASIC Stamp 2 (BS2)

- Specifications of interest:

- Good know-how by the team's members
- Good processor speed: 20 MHz
- Operating temperature range: -40 to +185 °F (-40 to + 85 °C)



Actuator: Parallax Standard Servo

- Specifications of interest:

- Holds any position between 0 and 180 degrees
- 38 oz-in torque at 6 VDC (0.268 N-m)
- Perfectly interfaced with PBASIC STAMP 2
- Simple to control with the PULSOUT command PBASIC
- Operating temperature range: +14 to 144 °F (-10 to 62 °C)

Actuator: Parallax Continuous Servo

- Specifications of interest:

- Bidirectional rotation
- 38 oz-in torque at 6 VDC (0.268 N-m)
- Perfectly interfaced with PBASIC STAMP 2
- Simple to control with the PULSOUT command PBASIC
- Low weight, 1.50 oz (42.5 g)
- Operating temperature range: +14 to 122 °F (-10 to 50 °C)

Sensor: Parallax Photoresistor, VT935G-B

- Specifications of interest:

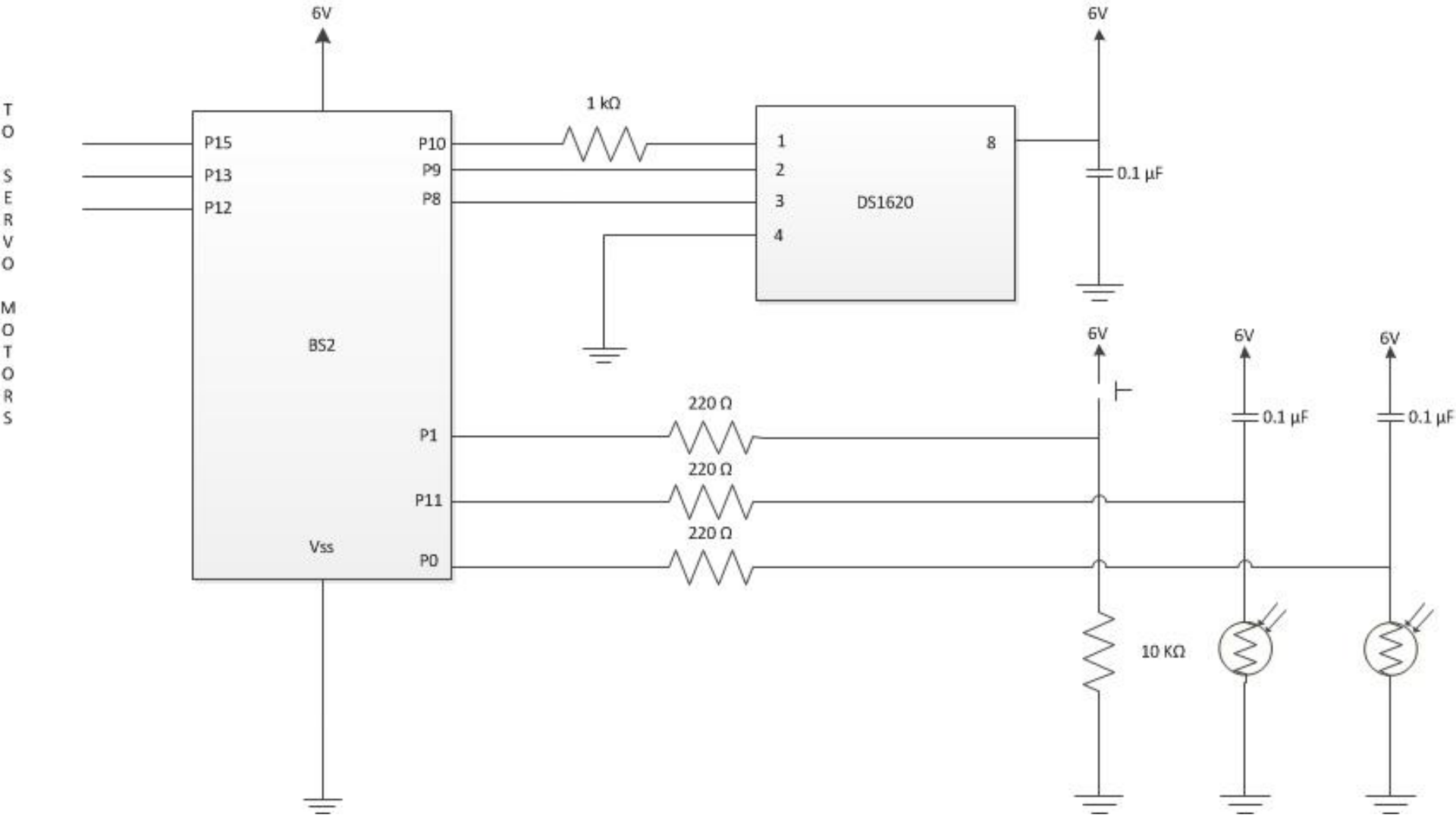
- Resistance in light condition ~ 20 kΩ
- Resistance in dark condition ~ 1 MΩ
- Rise time 35 ms
- Fall time 5 s

Sensor: Digital Thermometer, DS1620

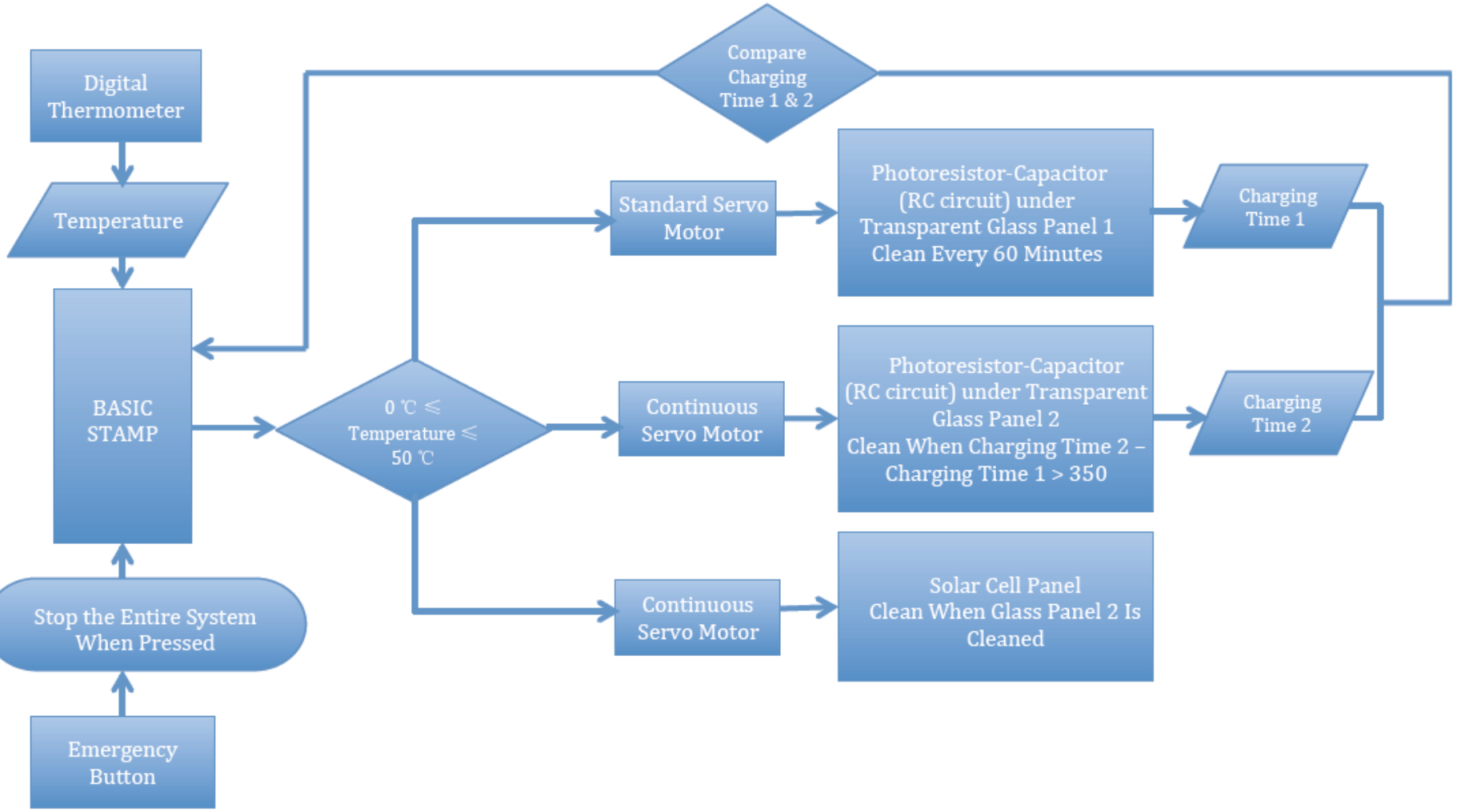
- <u>Specifications of interest:</u>

- Measures temperature within +/- 0.5°C error
- Perfectly interfaced with PBASIC STAMP 2
- Power requirements: 2.7 to 5.5 VDC
- Operating temperature range: -67 to +257 °F (-55 to +125 °C)

Circuit


6V
6V
1 kΩ
P15
P13
P12
P10
P9
P8
1
2
3
4
DS1620
8
0.1 µF
BS2
6V
6V
6V
220 Ω
220 Ω
220 Ω
P1
P11
P0
Vss
0.1 µF
0.1 µF
10 KΩ
TO SERVO MOTORS

Operational Flow Chart



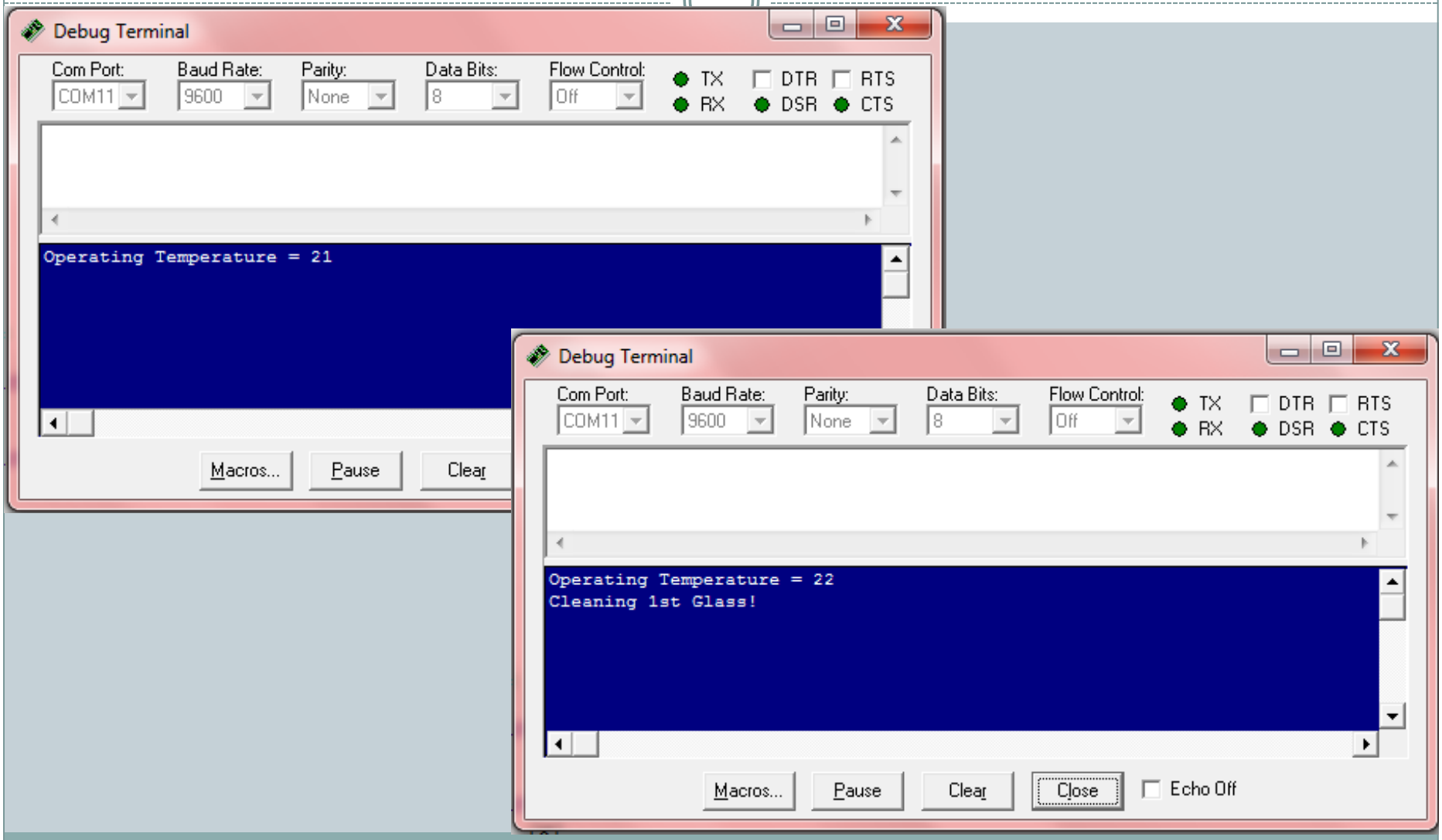
Prototype Cost

Item No.	Item Description	Unit Price ($)	Quantity	Total Price ($)
1	Board of Education with Basic Stamp 2	99.99	1	99.99
2	RadioShack® Universal Solderless Breadboard	24.99	1	24.99
3	Solar Panel	9.99	1	9.99
4	Photoresistor	1.99	2	3.98
5	Capacitor (0.1 µF)	0.15	3	0.45
6	Resistor	0.15	5	0.75
7	Wire	0.05	23	1.15
8	Servo Motor	12.99	3	38.97
9	Digital Thermometer (DS1620)	5.99	1	5.99
10	Button	0.50	1	0.50
11	Screw	0.50	1	0.50
12	Wooden Stick	1.67	1	1.67
13	Wooden Wedge	1.57	1	1.57
14	Glue	5.97	1	5.97
15	Batteries	0.50	4	2.00
			Total Cost ($):	**198.47**

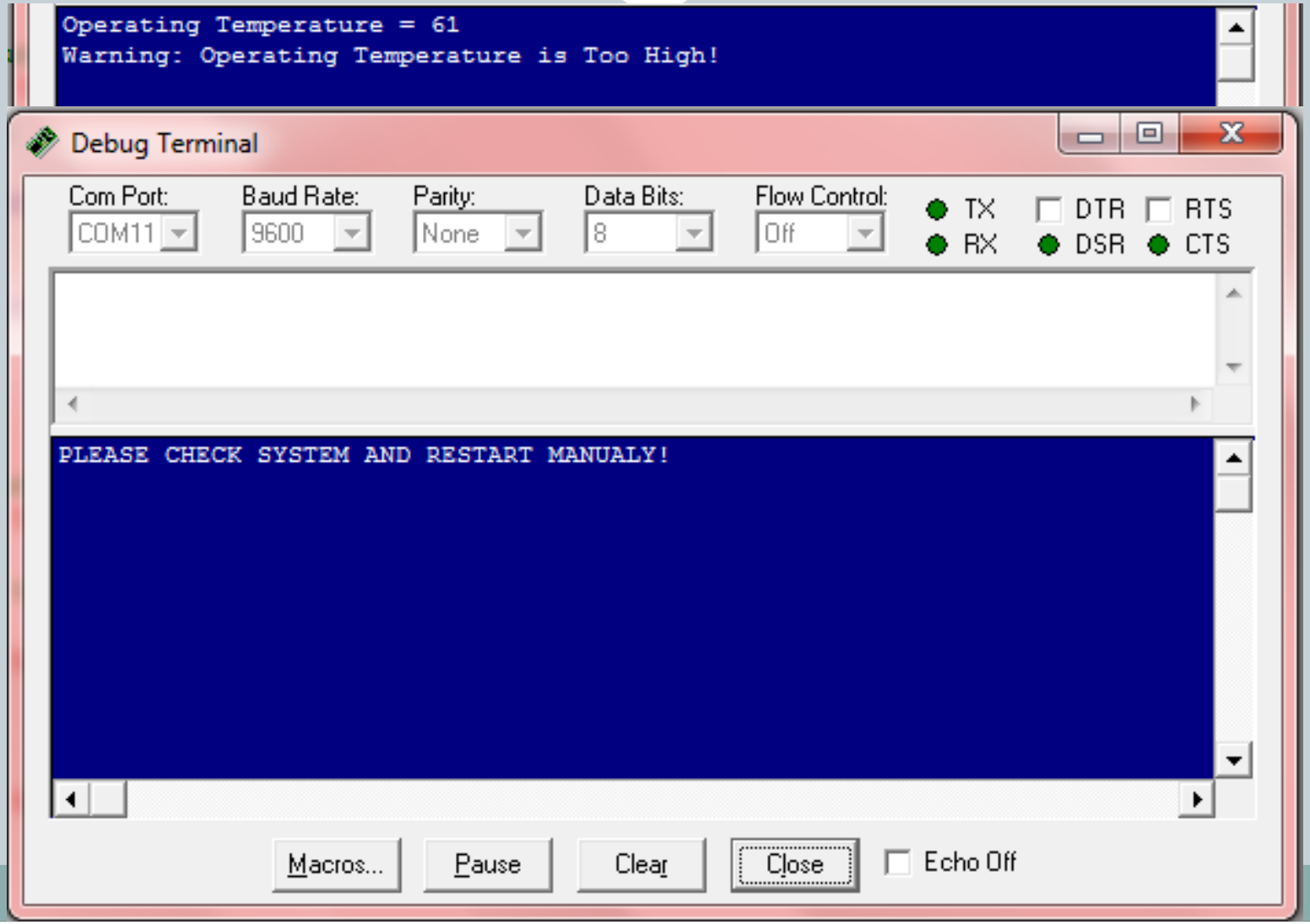
Demonstration

- We will now demonstrate our prototype!

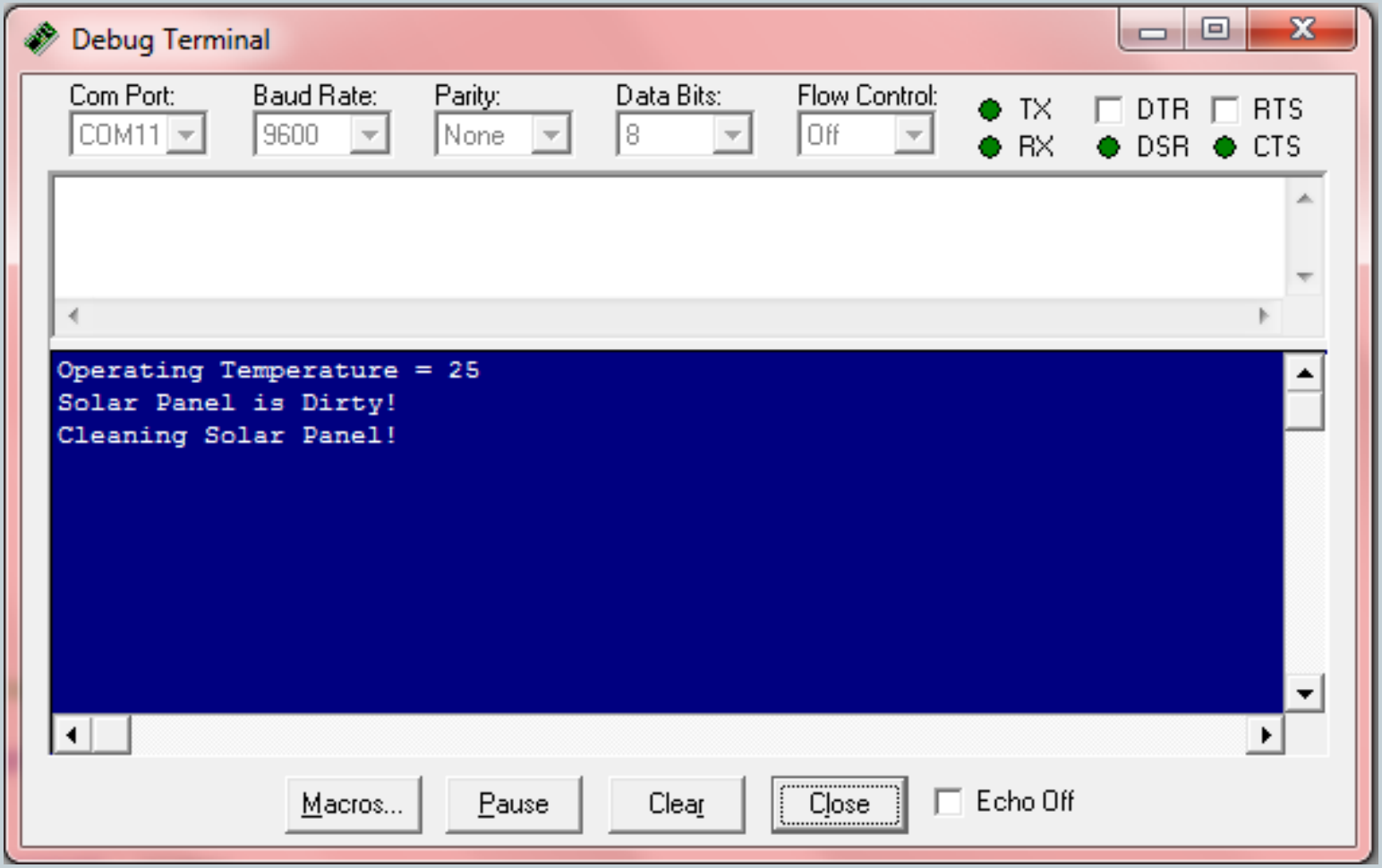
Cleaning 1st Glass



Operating Temperature



Cleaning Solar Panel



Advantages/Disadvantages

ADVANTAGES:

- Autonomous self-cleaning mechanism that can be attached to solar panels and operated without human operation
- Maximize the efficiency of the solar panels, resulting in these panels to pay-off earlier
- Easy to construct, low cost and low maintenance
- Allow for the system to be cleaned only when necessary

DISADVANTAGES:

- "Wiper Blade" which consists of an electrostatic cloth would need to be changed
- Needs to be scaled for larger projects (ex: increasing the torque of the motors)
- System is not powered by the photovoltaic cells; instead it is battery powered
- System used 2 continuous servo motors; standard servo motors are better.

Future Changes

- Design a better “wiper blade” so that changing it is required much less often and much easier. Also, increasing the contact force
- Interface the 9V solar panel with the BS2 to power the system using a regulator such as the LM7805
- Use 3 standard servo motors instead of continuous servos since we noticed that the continuous servos sometimes are a bit off, not always going back to the initial position

References

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Thank You!

QUESTIONS?