P14421:
Next Generation Smart PV Panel

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Problem:

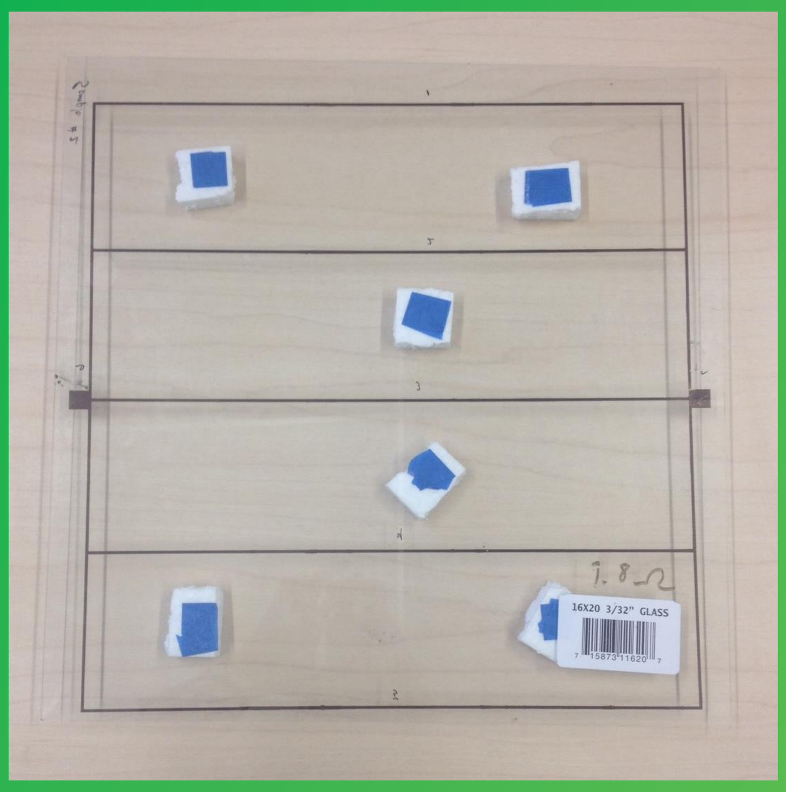
Design and build a smart PV panel prototype that utilizes heated conductive ink to melt snow that has collected on the panel, therefore preventing loss of energy production. System must be robust, energy efficient, and versatile.

Objectives:

- Working prototype with ink layout, control and heating systems
- System requires a minimum amount of power to operate
- System is robust: ink can survive the manufacturing process and system can operate in extreme climate
- Possible sensing methods explored
- Modular system: each panel has a dedicated snow-removal system

Full-System Design

Subsystems within Enclosure



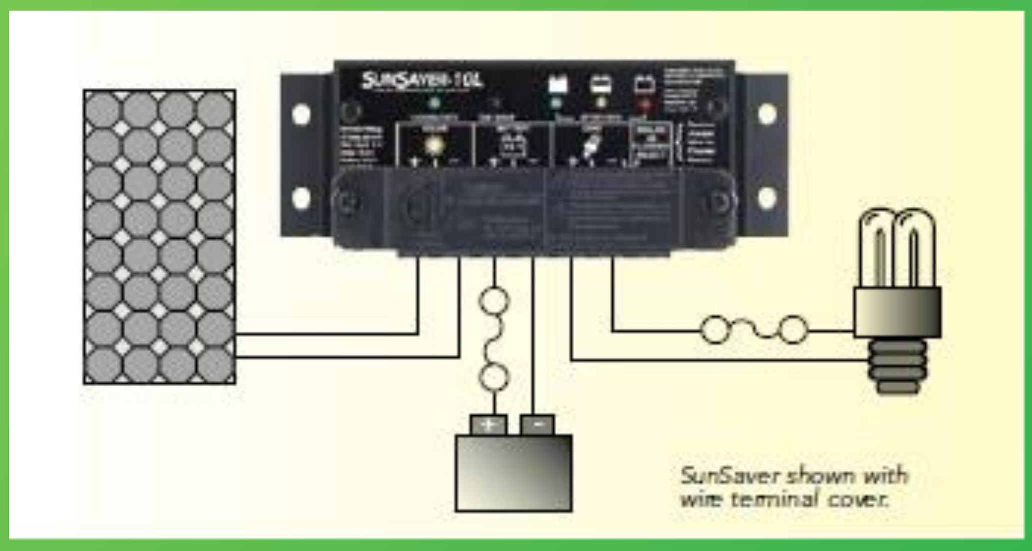
Glass Panel with Printed Ink Layout

How it Works:

- Sensor system determines whether it is energy-efficient for system to be running
- If conditions are good, the sensors tell the system to turn on through Arduino board
- Power stored in battery is used to heat ink traces
- Bottom layer of snow melts, allowing for snow to slide off of panel

- Silverline 22"H x 16"W x 10"D weather-proof enclosure
- 14" glass panel with 5 heating-trace ink layout

Power Electronics



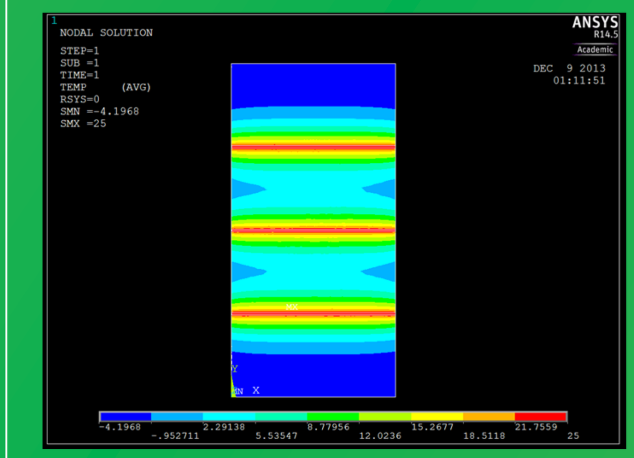
- Provide power to sensor conditioning circuits, system controller, and to ink to heat up the panel
- AGM 110AH battery
- Morningstar SS-20L charge controller
- Linear regulators
- Solid state relay: crydom series 1-DC D1D20

POC Control System

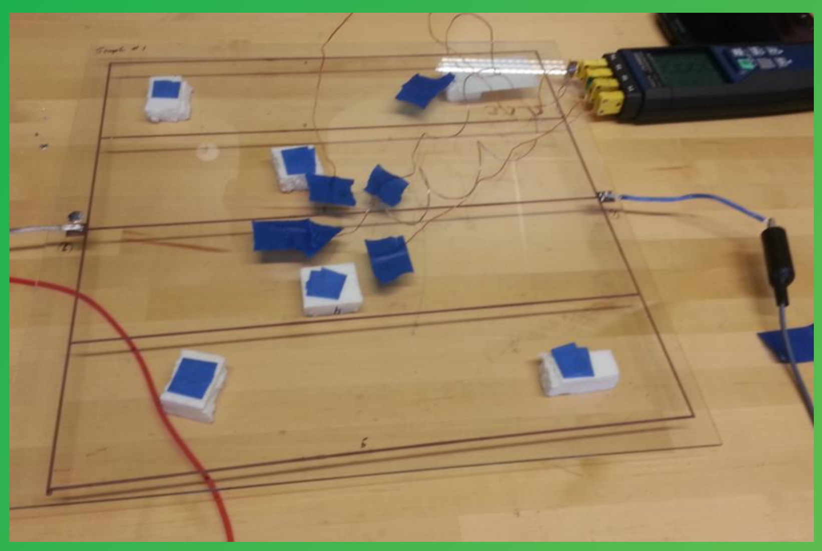
Atmel ATMEGA328P

- Processes signals from sensors
- Decides whether to melt snow or not
- Low power consumption mode
- Interfaces with the solid state relay cube to apply various amounts of power to the ink

Ink Layout



ANSYS Results of Final Layout



Printed Layout
(While undergoing heat testing)

- Layout design based on hand-calculations and ANSYS tests for ideal heat-spread
- Copper-based ink supplied by Intrinsiq Materials
- Hand-printed onto glass using custom screen
- Baked and then laser-cured to give it properties similar to copper
- Testing conducted to determine heat spread across panel, at both room temperature and under freezing conditions

Sensor System

Ambient light (GA1A2S100LY)

Ambient temp. (LM35)

- Sense light, temperature, and panel output voltage
- When temperature is below zero and panel output voltage is low, ambient light is observed
- If ambient light level is high enough to produce a reasonable amount of power, Individual comparators send interrupt signal to Arduino (see POC Control System)

Results and Recommendations

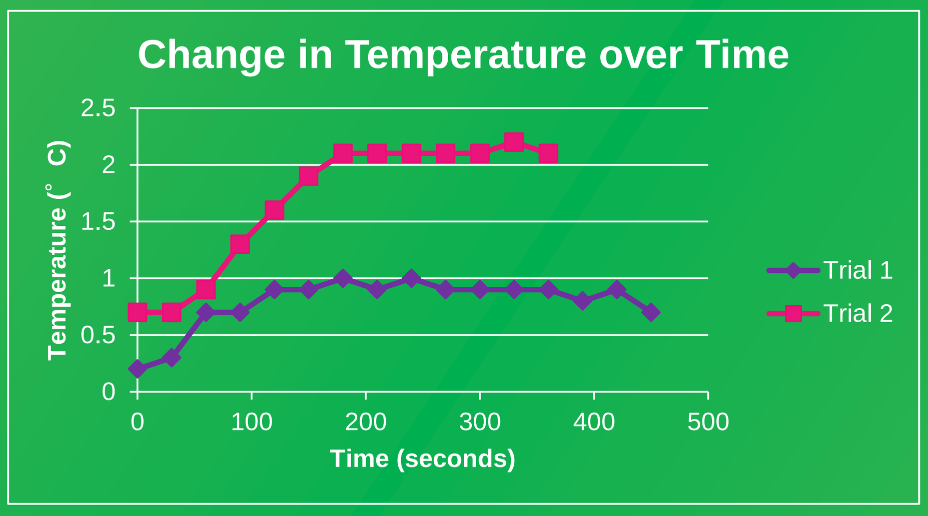


Figure: Change in temperature over time under freezing conditions with power input at 12 V.

- The current system doesn't perform well under freezing conditions.
- The current ink lacks required durability and may not survive the manufacturing process.
- Resistance and condition of ink is inconsistent because the traces were hand-printed and the laser-curing process was not uniform.
- Energy efficiency requirements not currently met.
- Future iterations of this project must work on finding a more durable, efficient ink, or look into alternative options for snow-removal.

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