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An Automated Approach to Passive Solar Evaporation

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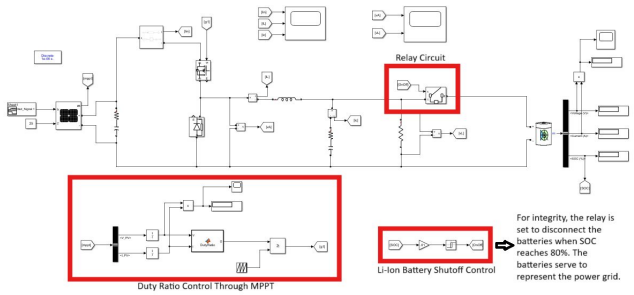
Introduction

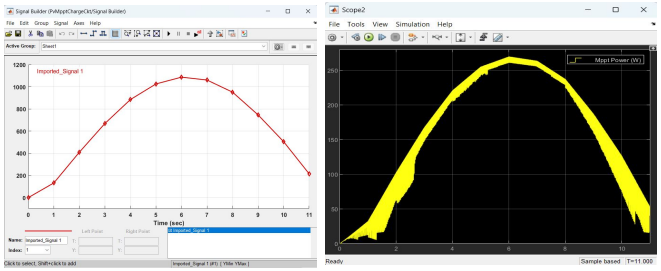
Processes such as chip manufacturing, battery reclamation, and nuclear power plants produce significant amounts of wastewater. To combat the increased demand for wastewater treatment, team 23 has proposed an automated enhanced solar evaporation system to replace the industrial standard of evaporation ponds. The proposed system capitalizes on the duality of solar energy utilizing solar heat flux to conduct evaporation on an increased surface area and the irradiation to power the electrical system.

PV MPPT Charge Circuit



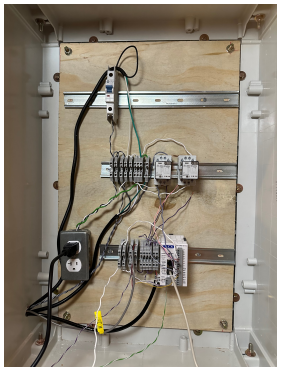
A 250W solar panel feeds a buck converter using maximum power point tracking to regulate the duty cycle. At peak irradiance, 1087.15 W/m^2, the buck converter maintains 24V and supplies 7.715A.

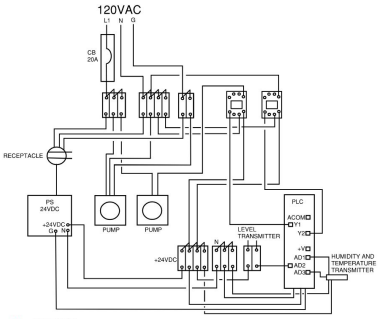
The efficacy of the circuit design is demonstrated through the mirror image of the solar irradiance in the MPPT regulated power (W).



CONTROL CIRCUIT

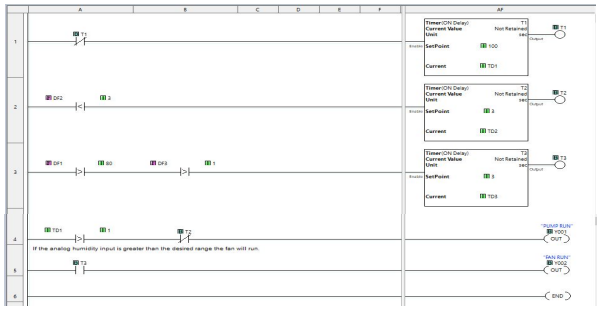
The enclosed system allows the evaporation rate to be controlled. The breaker protected circuit utilizes a programmable logic controller and relays to achieve an ideal environment for evaporation within the system.





PLC CONTROL LOGIC

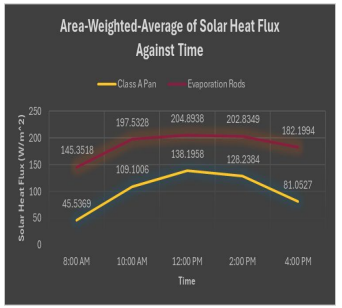
The PLC utilizes input ports to receive analog signals from a level transmitter and a humidity/temperature sensor. If the program reads an input from the level or humidity transmitter that is out of the intended range for an ideal environment, the program will send an output signal to the relays to start or stop the pump and fan. This PLC programming allows for fully autonomous control of the system.

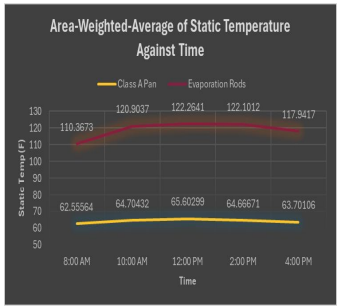


Evaporation Testing and Results

Natural evaporation typically occurs only at the water-air interface when the molecules accumulate enough energy to phase change. Applying this, conical evaporation rods inspired by biomimicry serve as heating elements increasing the water-air interface by adding a vertical element.

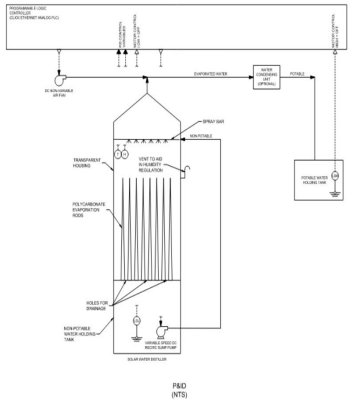
The results are compared against a Class A pan to represent evaporation ponds.





The solar ray tracing radiation model simulations show the solar heat flux and static temperature resulting from the incident radiation is approximately 2x that of the evaporation pond water-air interface.

Conclusion



- Final build reflects simulation results with increased magnitude of evaporation rate
- Solar circuit successfully supplies 24V to PLC and charges batteries at max power
- PLC programming with set points for humidstat and level sensor, accomplishes regulated evaporation and instrument protection