NAU Solar Capstone

Operation Manual

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Introduction

The NAU Solar Capstone team has spent the Spring and Fall 2020 semester developing a solar system to heat the Engineering building on the campus of Northern Arizona University. The system consists of an array of evacuated tube solar collectors that utilize solar energy that can be converted into heat for the building by passing through a heat exchanger. The team developed a test during the fall semester to determine the production of a single panel, where data could be extracted to determine the feasibility of the entire system. The following manual provides instructions regarding the assembly and operation of the experimental procedure.

Experiment Overview

The objective of the test was to gather data regarding the temperature change, pressure change, and flow rate of the water as it travels through the panel. As heat is collected in the tubes of the panel, the water flowing through the manifold at the top of the panel heats up.

To measure the temperature change through the panel, a thermocouple was installed at the inlet and outlet of the panel with appropriate valve fittings. The thermocouples were connected to a computer with LABVIEW software that was set up to collect temperature at predetermined increments of time. The pressure was measured manually at the inlet and outlet of the panel using pressure gauges that measure in pounds per square inch (psi). The pressure gauges provide constant readings as the water enters and leaves the system. Lastly, to measure the flow rate, the team took time measurements by hand and marked the rate of flow into the hydraulic bench, which was measured in liters per second.

By recording data throughout the day of the test, the team was able to develop an understanding of the production of the panel as the sunlight varied. During the testing period, the team was present to monitor the system and ensure it was properly operating and tracking data. The following section outlines the materials needed and the process of setting up and operating the experiment.

Materials List

Material	Quantity
K-type Thermocouple	2
K-type Thermocouple Wire	~40ft
Sunmaxx VHP30 Solar Panel	1
Pressure Gauges (.5psi resolution)	2
Garden Hose	(2) 7.5ft pieces
Galvanized T-fittings	4
1” x ¾” Galvanized Reducer	2
¾”x 6” Galvanized Nipple	2
¾”x close Galvanized Nipple	6
¾” x ⅜” Galvanized Hex Bushing	2
Garden Hose Swivel Adapter	2
1”x 3/4” PVC Hex Bushing	1
DAQ Receiver Bridge	1
Hydraulic Bench	1
Teflon Tape	~100ft

Testing Assembly

To properly operate the panel test, the system must be safely assembled. The entire testing system consists of the following components.

- Evacuated tube panel attached to wooden mount
- Pressure Gauges (2)
- Thermocouples (2)
- Proper valve fittings used to attach the pressure gauges, thermocouples, and hoses to the panel at each end.
- Hydraulic bench to hold water before and after it leaves the panel
- Hose to transport water from the Engineering building to the hydraulic bench, located in the Solar Shack
- Hose at each end of the panel to transport water between the panel and the bench

Operation

To properly run the experiment, it is necessary to first set it up and ensure all of the valves are attached safely. The following images show the proper configuration of the testing system.

Figure 1. Full testing system

Figure 2. Configuration of hose connected to bench and panel

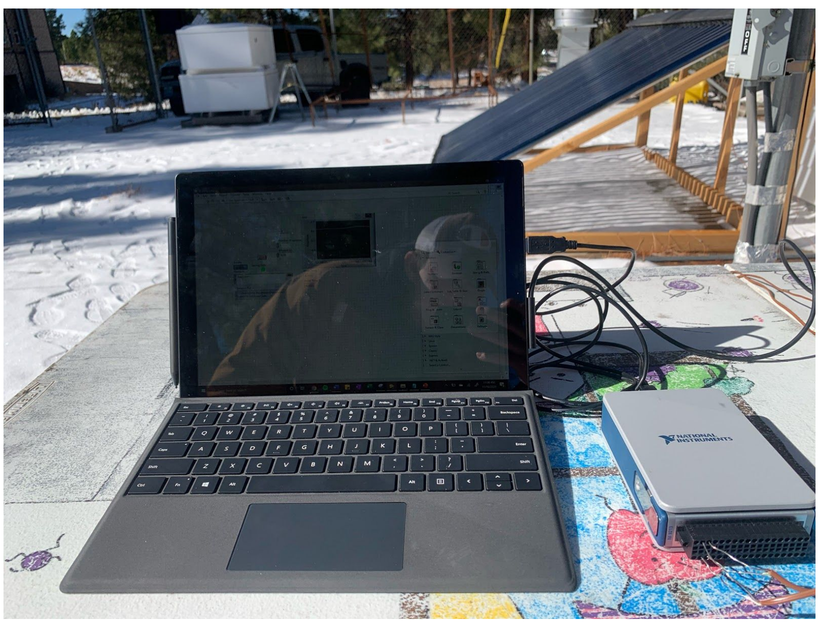

Figure 3. LABVIEW system connected to thermocouples

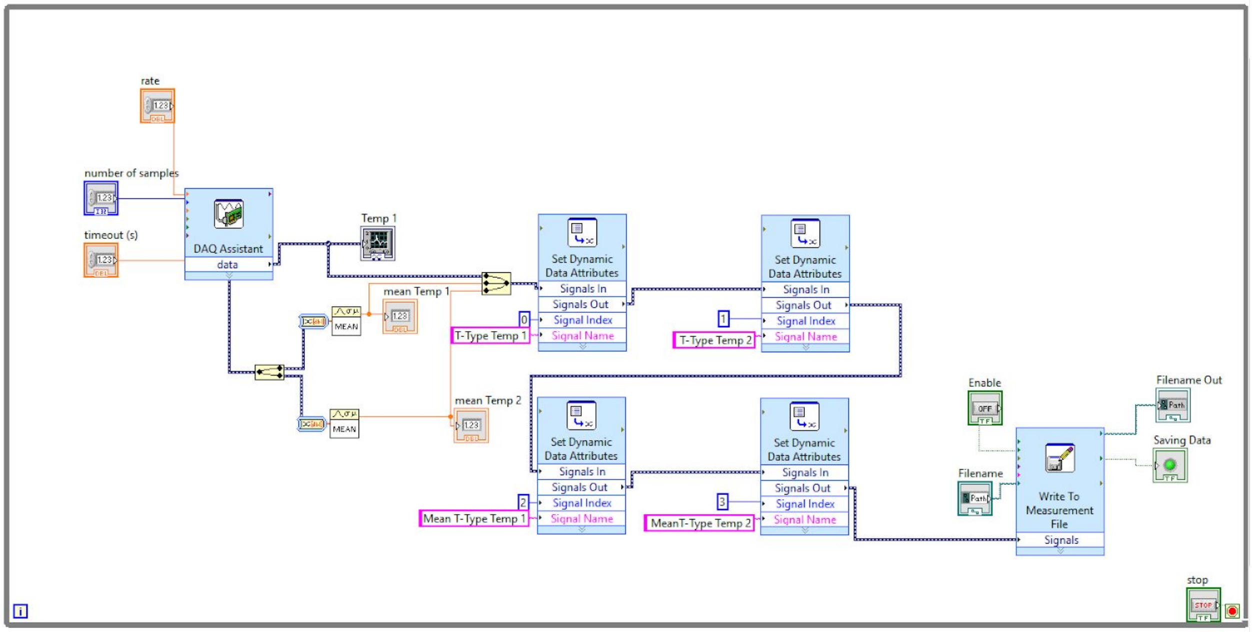

Figure 4. LABVIEW VI Block Diagram

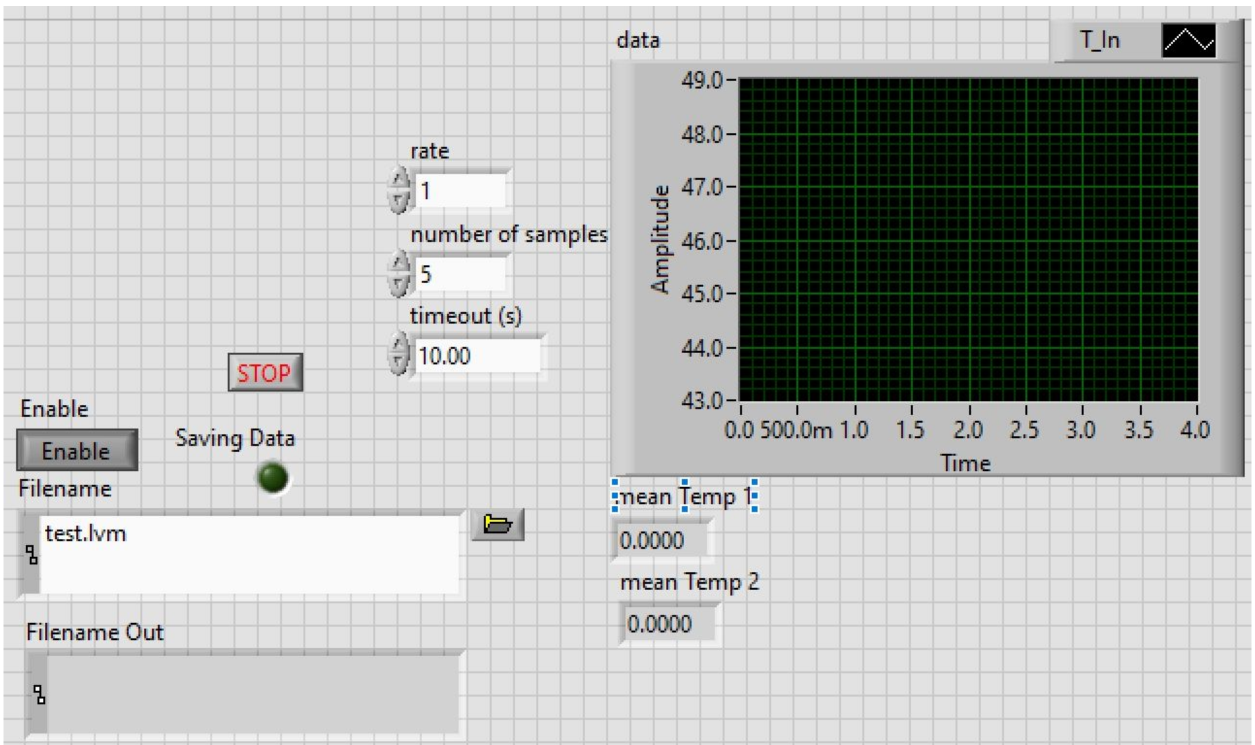

Figure 5. LABVIEW VI Front Panel

The following section describes the process of assembling and operating the test.

1. Obtain the following instruments from lab 111 of the Engineering building and move them to the Solar Shack where testing will take place:
    a. Hydraulic bench
    b. K-Type Thermocouples (2)
    c. Pressure Gauges (2)
    d. DAQ
    e. K-Type thermocouple wire

   Safely roll the Hydraulic Bench up the access road that leads from the Engineering building parking lot to the Solar Shack.

2. Connect the 1”x3/4” hex bushings to both the inlet and outlet of the panel to convert the piping from 1” to ¾”. Connect close nipples on both sides of the t-fittings and attach at the inlet and the outlet hex brushing. Connect another T-fitting onto the outside close nipple at the inlet and the outlet. Connect the final close nipples to the outside T-fittings. Connect the Garden Hose Swivel adapters to these close nipples so that they are the outermost fittings on the system. Connect the 6” nipples to the inside T-fittings to create the thermocouple housing. Screw the thermocouples onto these nipples. Connect the ¾” x ⅜” hex brushing to the outside T-fittings at the inlet and outlet. Connect the pressure gauges to these hex bushings. The system will now have pressure gauges on the outside (relative to the panel) of the thermocouples at both the inlet and outlet. Connect (1) 7.5ft garden hose section to the inlet garden hose swivel and connect the PVC hex bushing to the other end of the hose. Connect the PVC hex bushing to the pump. Connect the other garden hose to the outlet garden hose swivel and place the other end of the hose in the reservoir of the hydraulic bench.
    i. Ensure that the fittings are tightly screwed on to avoid leaks. Use a wrench to sufficiently tighten them. PTFE tape should be used on all threaded connections to prevent leaks as well.

3. Fill the hydraulic bench with water from the spigot on the Engineering building. The long hose in the Solar Shack is long enough to run from the spigot to the testing area. A water key must be obtained from the engineering front desk to turn the water on. The bench should be filled sufficiently to the first reservoir fill line.

4. After the bench is filled and the instruments are correctly fastened to the panel, turn on the bench to get water to begin pumping into the system. The flow rate

can be manually changed by turning the dial on the side of the bench, ensuring a sufficient flow rate of 0.84 +/- .05 GPM.

    i. Ensure the hose connecting the hydraulic bench to the test set-up is not kinked so that constant flow rate may be achieved.

5. To measure the flow rate of the water out of the panel, the bucket timer method is used.
    a. Predetermine a volume of water to be measured
    b. Start a timer to start the test and stop the timer when the water level reaches the determined volume.
    c. The hydraulic bench has a measurement device that shows the water level which can be used for this measurement.

6. Run water through the system until the system has reached steady state.

7. Take down manual pressure readings on the Pressure Gauges at the inlet and outlet as the water is pumped through the system.

8. Ensure that the LABVIEW system is taking temperature readings for both thermocouples.
    a. Connect the thermocouples so that the ends are in line with flow of water.
    b. Connect thermocouple receivers to thermocouples.
    c. Connect K-Type thermocouple wire to DAQ Receiver Bridge.
    d. Plug DAQ Receiver Bridge (with compatible USB-A cord) into laptop.
        i. Ensure all thermocouples are correctly hooked up with positive and negative wires connected respectively.
        ii. Ensure the connections from the K-Type thermocouple wire to the DAQ Receiver Bridge are not touching or crossed, as this will yield ineffective measurements.
        iii. Ensure the VI used to measure runs inside a while-loop to continuously record data, and confirm that the write to measurement file is set to only write one title so that data may be more effectively manipulated and graphed.

9. Extract data from LABVIEW as a .lvm file and export it into an Excel file to manipulate the data to gather results.
    a. Open Excel to a new or desired page
    b. Locate saved .lvm file and drag this file into the Excel page.
        i. Ensure LABVIEW data is saved as a .lvm file rather than a .txt file, as this is the only way to effectively gather data in Excel.