

## INTRODUCTION

A Spice modeling of a Thermoelectric Generation (TEG) system was investigated. The whole thermal process was first tested and then converted to an equivalent electrical circuit.

The thermal parameters (Capacitors, resistors and inductances, etc.) were extracted from Datasheet, Device geometries, and Material properties. The most commonly thermal to electrical analogies were utilized to construct the electrical circuit of the thermal setup. The TEG was first run to generate some power and then through the reverse polarity method, it was run as a Thermoelectric Cooler (TEC). A differential temperature of  $\Delta T = 13.43^\circ\text{C}$  was achieved.

- The TEM is made of semiconducting materials ( $\text{Bi}_2\text{Te}_3$ )
- The ceramic substrate is made of alumina ( $\text{Al}_2\text{O}_3$ )

## BACKGROUND WORKS

The purpose of this work was to first demonstrate the feasibility of an LTspice modeling of a Thermoelectric Module (TEM) and then to investigate how TEG system behaves in real-world. First, the TEM was run as a heat pump (TEC) by sending it a variable DC voltage. Second, the TEM was simulated as accurately as possible by considering the internal intrinsic parameters. Among all the physical phenomena that take place in a TEM, the most dominant mechanisms were considered (i.e., Seebeck, Peltier, and Joule effects). The Thomson effect was neglected.



FIGURE 1: EXPERIMENTAL SETUP

## METHODS

- Analytical Transient Heat Transfer is **Cumbersome**
- Numerical method was proposed
- Thermal to Electrical analogy was utilized
- LTspice software simulator was proposed and used
- A lookup table of real data ( $T_H$  and  $T_L$ ) was created
- Data were fed into the built-in piecewise linear (PWL) command
- The latter scheme improved the simulation speed
- Experimental and simulated results were compared

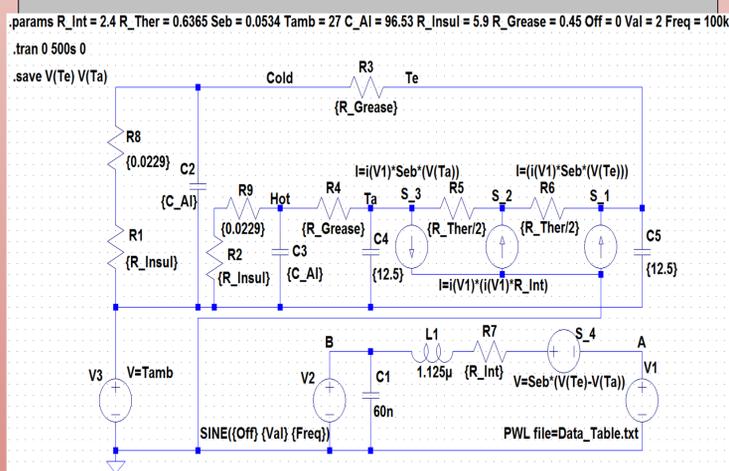


FIGURE 2: LTSPICE MODEL OF THE TEM WITH THE INTERNAL PARASITIC L&C VALUES

## THE SEVEN TEG SPICE MODELING STEPS

### 1. Identify all the Components

### 2. Calculate the Biot Number

(Its value determines the approach to be adopted in the analysis.

- $Bi$  much less than unity, the lumped capacitance method is solely recommended for accuracy in the results.
- $Bi$  isn't much less than, then some sort of numerical discretization method should be considered).

### 3. Calculate the thermal R and C

### 4. Define and draw parasitic elements ( L, C)

### 5. Express the Electrical equivalence of thermal parameters

### 6. Connect the analogy blocks in series-parallel

### 7. Run the TEG in LTspice

## RESULTS

- The TEG parameters were successfully extracted
- A Spice model of the whole Thermal process (TEM, Thermal resistances, inductances, and capacitances) was elaborated through electrical equivalence schemes. The electrical model is shown in Fig. 2.
- A significant temperature difference was developed across the two sides of the TEM as can be seen in Fig. 3 in a short period of time. The maximum differential value attained within that short period of time was  $13.43^\circ\text{C}$ .
- The TEM device performed perfectly as a heat removal device, i.e. a thermoelectric Cooler (EC).

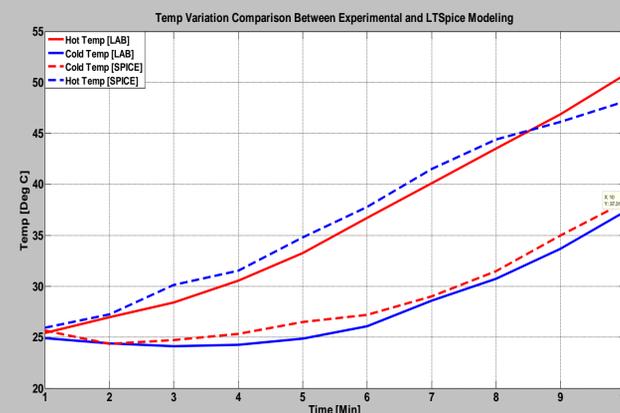


FIGURE 3: COMPARATIVE EXPERIMENTAL AND SIMULATED TEMPERATURE PROFILE

## CONCLUSIONS/FUTURE WORK

- An experimental setup was designed and built to characterize and study the performance of a commercial TEM. An LTspice TEM modeling scheme was developed through thermal to electrical equivalence strategies
- A complete Thermo-electric Generation System is setup on the roof of the Engineering building at UNLV to harvest the free solar energy. The main components are: 5 TEGs, Datalogger, Tracker, Pyrheliometer, 2 Thermocouples, wind speed and direction sensors, a relative humidity sensor, a flux sensor, A DC-DC Converter, and a battery bank (Fig.4)
- The aim of this work (solar TEG) is to investigate ways for energy delivery to remote residential areas in arid and/or developing regions.

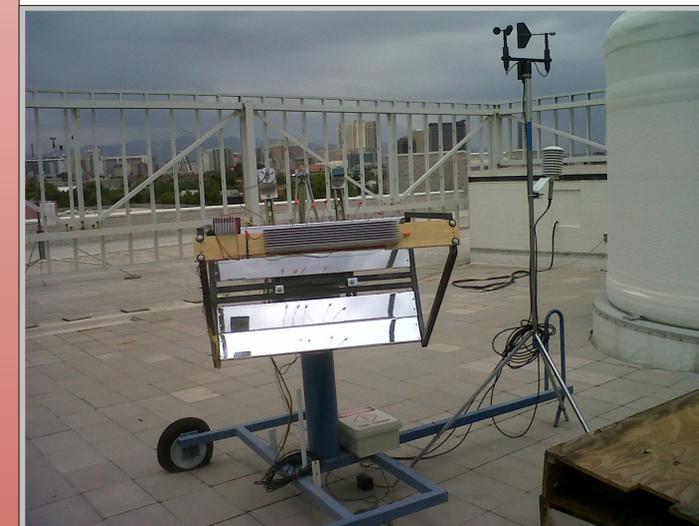


FIGURE 4: COMPLETE ENERGY HARVESTING SYSTEM

## REFERENCES

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