HOA 1 – Evaluating the use of Peltier modules for practical applications

Submit only one worksheet per group. Due date: 19 March 2020 at 6 pm

Questions:

Part 1: Peltier effect – TEC Heat pump mode (non-spontaneous heat transfer)

(1) Draw a schematic like figure 3 or 4 to represent the process in part 1. Using the first law of thermodynamics, write an energy balance to account for all the heat and work in this TEC process. (1 point)

Use:
$\dot{W}$ - power input
$\dot{Q}_h$ - rate of heat transfer at hot end
$\dot{Q}_c$ - rate of heat transfer at cold end

(2) Comment on the trends of the current and temperature difference as the experiment progresses. (1 point)

Part 2: Seebeck effect – TEG Heat engine mode (spontaneous heat transfer)

(3) Draw a schematic like figure 3 or 4 to represent the TEG process. Using the first law of thermodynamics, write an energy balance to account for all the heat and work in this TEG process. Is this energy balance the same as that of a TEC? (1.5 points)

(4) Using the data collected for your first load resistor, plot the a) output power ($\dot{W}$) vs. time, b) T_h vs. time and c) T_c vs. time graphs. What are the reasonable equations that can be used to represent $\dot{W}$, and T_h and T_c as a function of time?
Hint: Should T_h be an exponential, log or polynomial curve? Note that T_h will never get to 0 (offset), manual offset to the room temperature must be done. (4.5 points)

(5) Using the equations for T_h and T_c, write the equations for $\dot{Q}_{\mathrm{h}}$ and $\dot{Q}_{\mathrm{c}}$. Plot a) $\dot{Q}_{\mathrm{h}}$ vs. time and b) $\dot{Q}_{\mathrm{c}}$ vs. time graphs. Attach these five graphs (Q4 and 5) to the worksheet. They can be plotted together but label them clearly. (3 points)

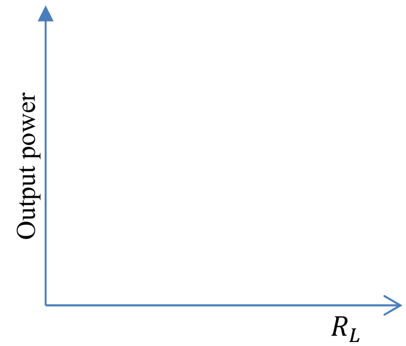
(6) Is the energy balanced based on (5)? Suggestion a reason for your observation? (2 points)

(7) For the first load resistor, what is the total energy used to create the temperature differential/gradient during the heat pump phase? You may use an average power input to estimate this. (1 point)

(8) For the first load resistor, what is the total energy output derived during the Heat Engine phase? Energy output can be calculated using the output power vs. time graph in (4). (1 point)

(9) Calculate the percentage of energy input during the Heat Pump phase that was recovered as useful work during the Heat Engine phase for the <u>first</u> load resistor. (1 point)

(10) $\dot{W} = \frac{V_{out}{}^2}{R_L} = \left[\frac{\Delta V_{Se}{}^2 R_L}{(R_{in}+R_L)^2}\right]$ for a TEG. Show that to ensure maximum output power ($\dot{W}_{max}$) is delivered, the load resistor, R_L applied must be equal to R_{in}. What is $\dot{W}_{max}$? Sketch the shape of the expected output power vs. resistance graph. (4 points)



(11) Choose one appropriate ΔT for calculation of the output power at different load resistance. Complete the table below:

	Resistance of the Load resistor (Ω)	Output power ($\dot{W}$) at ΔT = _______
1		
2		
3		
4		
5		
6		
7		
8		
9		

Plot the Output power vs. resistance graph. Attach the graph to this worksheet. Is this the same trend as the expected output power vs. resistance graph in (10)? (3 points)

(12) Predict how your output power at ΔT =__________ would differ if you repeat your analysis using a larger ΔT? (1 point)

(13) Is the setup a good way to store energy? Explain. (1 point)