EE/CprE/SE 491 WEEKLY REPORT 05

3/16/2020 – 4/12/2020

Group number: 08

Project title: High Resolution Digitally Trimmable Resistor

Client &/Advisor: Prof. Randy Geiger

Team Members/Role: Clark Reimers - Test Engineer, Pierce Nablo - Design Engineer, Alek Benson - Information Manager, Oluwatosin Oyenekan - Meeting Lead
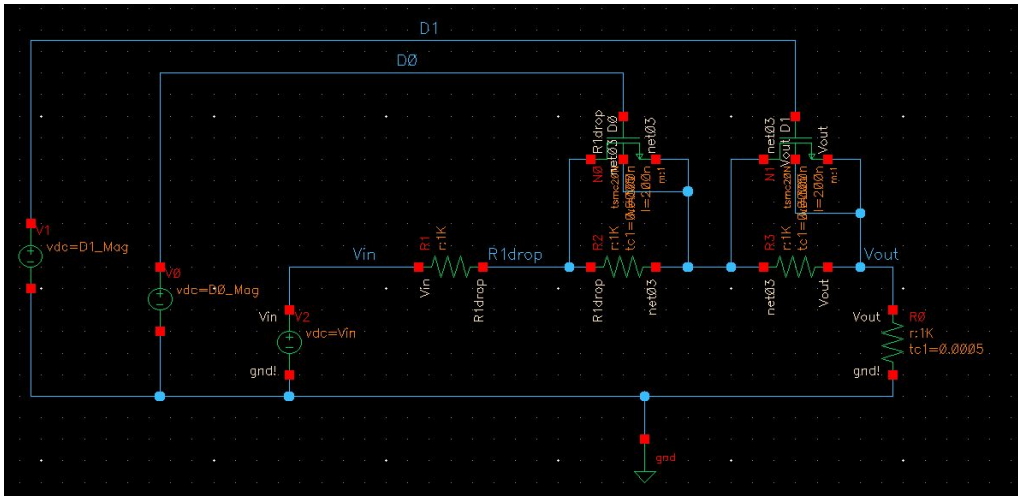

❖ **Weekly Summary**

      During the past 4 weeks our group had to tackle many issues related to going remote. We went remote due to Iowa State shutting campus down because of the COVID-19 situation. Therefore during the first few weeks of this period we migrated our entire structure to an online environment including access to Virtuoso, access to shared files, and meetings. Once all of the bugs were worked out with remote access, we then began to simulate the temperature coefficient of a resistor and a resistor divider structure. While doing so we ran into issues where the simulation environment would manipulate our temperature coefficients to a function dependent on temperature but we wanted it to be represented by a constant, independent of temperature.
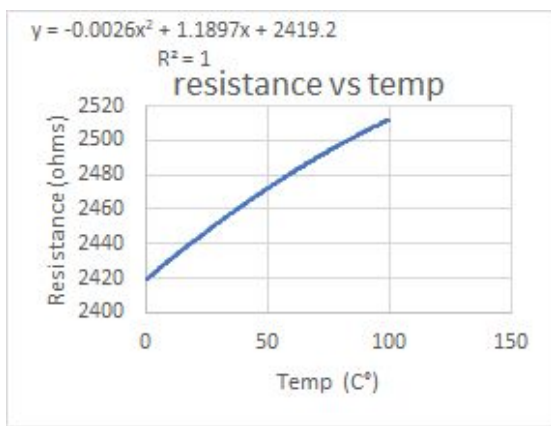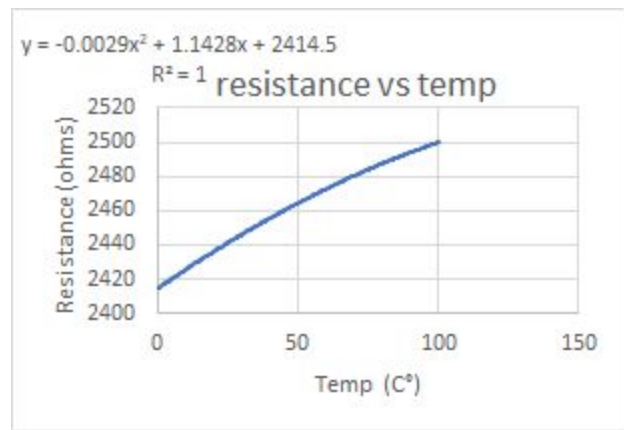
❖ **Past week accomplishments**

Clark Reimers:
- General troubleshooting with the changeover to online everything.
- Assisted team members with technical troubleshooting
    - RDP issues, VPN issues, Virtuoso issues, etc.
- Assisting with finding the temperature coefficient for the single resistor and took it to simulations.
    - Troubleshooting the temperature coefficient not being a constant with our testing.
        - Determined that the equation Virtuoso used was different than the ones we were using for calculations.
- Assisted with finding the temperature coefficient equations for the resistor divider structure in its 4 different states after establishing the coefficient for the resistor.

Resistor divider structure

$y = -0.0026x^2 + 1.1897x + 2419.2$

$R^2 = 1$

D0 on, D1 off

$y = -0.0029x^2 + 1.1428x + 2414.5$

$R^2 = 1$

D0 off, D1 on

$y = 2960.7e^{0.0005x}$

$R^2 = 1$

D0 off, D1 off

$y = -0.0055x^2 + 1.825x + 1851.9$

$R^2 = 1$
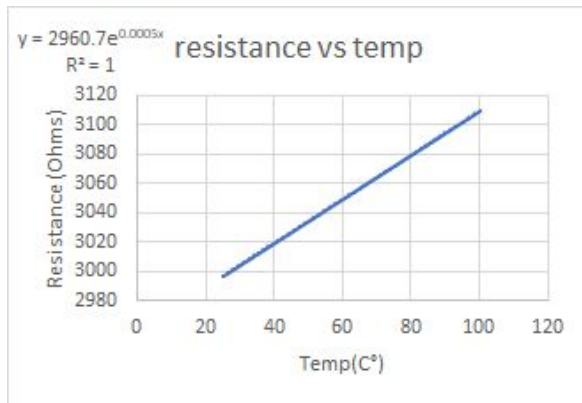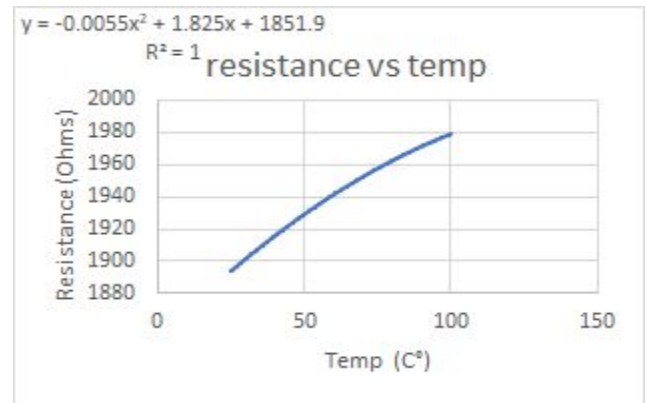
D0 on, D1 on

- Started working on expanding to larger scale circuits
- Presented with my group to Dr.Geiger
- Completed weekly assignments and participated in Lightning take

Pierce Nablo:
- Worked on getting vpn to work
- Worked on getting remote access to work
- Troubleshooted issues with running Virtuoso remotely
- Troubleshooted issues with getting SPECTER to run remotely
- Simulated a basic resistor to debug why our temperature coefficient is not acting as a constant.

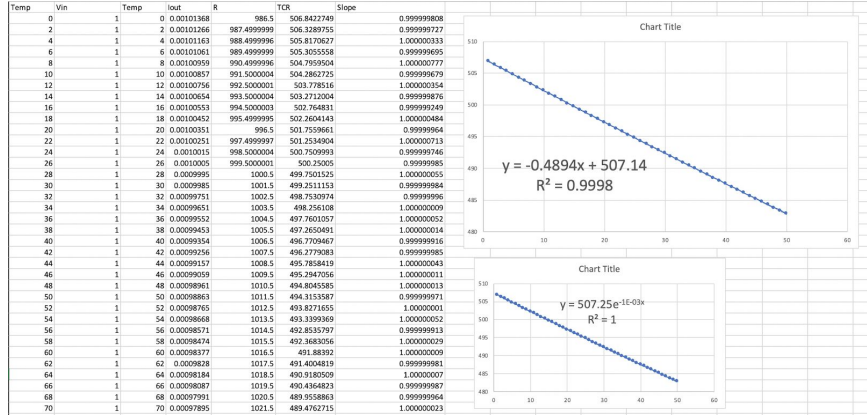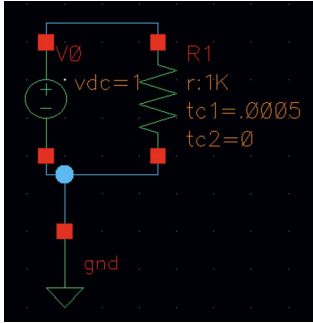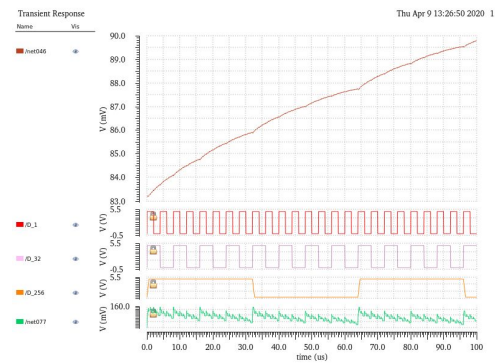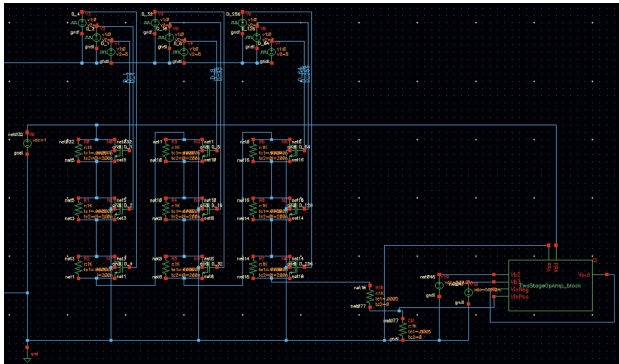| Temp	Vin	Temp	Iout	R	TCR	Slope
0	1	0	0.00101368	986.5	506.8422749	0.999999808
2	1	2	0.00101266	987.4999999	506.3289755	0.999999727
4	1	4	0.00101061	988.4999996	505.8170627	1.000000333
6	1	6	0.00101061	989.4999999	505.3055558	0.999999695
8	1	8	0.00100959	990.4999996	504.7959504	1.000000777
10	1	10	0.00100857	991.5000004	504.2862725	0.999999679
12	1	12	0.00100756	992.5000001	503.778516	1.000000354
14	1	14	0.00100654	993.5000004	503.2712004	0.999999876
16	1	16	0.00100553	994.5000003	502.764831	0.999999249
18	1	18	0.00100452	995.4999995	502.2604143	1.000000484
20	1	20	0.00100351	996.5	501.7559661	0.99999964
22	1	22	0.00100251	997.4999997	501.2534904	1.000000713
24	1	24	0.0010015	998.5000004	500.7509993	0.999999746
26	1	26	0.0010005	999.5000001	500.25005	0.99999985
28	1	28	0.0009995	1000.5	499.7501525	1.000000055
30	1	30	0.0009985	1001.5	499.2511153	0.999999984
32	1	32	0.00099751	1002.5	498.7530974	0.99999996
34	1	34	0.00099651	1003.5	498.256108	1.000000009
36	1	36	0.00099552	1004.5	497.7601057	1.000000052
38	1	38	0.00099453	1005.5	497.2650491	1.000000014
40	1	40	0.00099354	1006.5	496.7709467	0.999999916
42	1	42	0.00099256	1007.5	496.2779083	0.999999985
44	1	44	0.00099157	1008.5	495.7858419	1.000000043
46	1	46	0.00099059	1009.5	495.2947056	1.000000011
48	1	48	0.00098961	1010.5	494.8045585	1.000000013
50	1	50	0.00098863	1011.5	494.3153587	0.999999971
52	1	52	0.00098765	1012.5	493.8271655	1.000000001
54	1	54	0.00098668	1013.5	493.3399369	1.000000052
56	1	56	0.00098571	1014.5	492.8535797	0.999999913
58	1	58	0.00098474	1015.5	492.3683056	1.000000029
60	1	60	0.00098377	1016.5	491.88392	1.000000009
62	1	62	0.0009828	1017.5	491.4004819	0.999999681
64	1	64	0.00098184	1018.5	490.9180509	1.000000007
66	1	66	0.00098087	1019.5	490.4364823	0.999999987
68	1	68	0.00097991	1020.5	489.9558863	0.999999964
70	1	70	0.00097895	1021.5	489.4762715	1.000000023

Chart Title

$y = -0.4894x + 507.14$
$R^2 = 0.9998$

Chart Title

$y = 507.25e^{-1E-03x}$
$R^2 = 1$

- Made a large series resistor design to have a better reference to compare other designs too for the future.


- Presented to Dr. Geiger the simulation results
- Made the Lightning talk video
- Completed weekly assignments for EE491

Alek Benson:
- Continued reviewing 330/435 material.
- Continued researching different trimming technologies
- Worked on setting up a Virtuoso environment on a remote desktop.
- Worked on getting Cadence software implemented in Virtuoso
- Worked on getting a sharepoint library through one drive to hold some excel data files.
- Worked on the simulating temperature coefficient of the series resistor trimming structure.
- Worked on the schematics for the ladder structure and simulating in Cadence.
- Worked on the Temperature Coefficient formula in Cadence and resolving the real life model of Temperature Coefficient of a basic resistor.

/net1 X	/net1 Y	/R0/PLUS	/R0/PLUS	res	TCR	TCR2
25	1	25	0.001001	999	500.5005	500
25.5	1	25.5	0.001001	999.25	500.3753	500
26	1	26	0.001001	999.5	500.2501	500
26.5	1	26.5	0.001	999.75	500.125	500
27	1	27	0.001	1000	500	500
27.5	1	27.5	0.001	1000.25	499.875	500
28	1	28	0.001	1000.5	499.7501	500
28.5	1	28.5	0.000999	1000.75	499.6253	500
29	1	29	0.000999	1001	499.5005	500
29.5	1	29.5	0.000999	1001.25	499.3758	500
30	1	30	0.000999	1001.5	499.2511	500
30.5	1	30.5	0.000998	1001.75	499.1265	500
31	1	31	0.000998	1002	499.002	500
31.5	1	31.5	0.000998	1002.25	498.8775	500
32	1	32	0.000998	1002.5	498.7531	500
32.5	1	32.5	0.000997	1002.75	498.6288	500
33	1	33	0.000997	1003	498.5045	500
33.5	1	33.5	0.000997	1003.25	498.3803	500
34	1	34	0.000997	1003.5	498.2561	500
34.5	1	34.5	0.000996	1003.75	498.132	500
35	1	35	0.000996	1004	498.008	500
35.5	1	35.5	0.000996	1004.25	497.884	500
36	1	36	0.000996	1004.5	497.7601	500
36.5	1	36.5	0.000995	1004.75	497.6362	500
37	1	37	0.000995	1005	497.5124	500
37.5	1	37.5	0.000995	1005.25	497.3887	500
38	1	38	0.000995	1005.5	497.265	500

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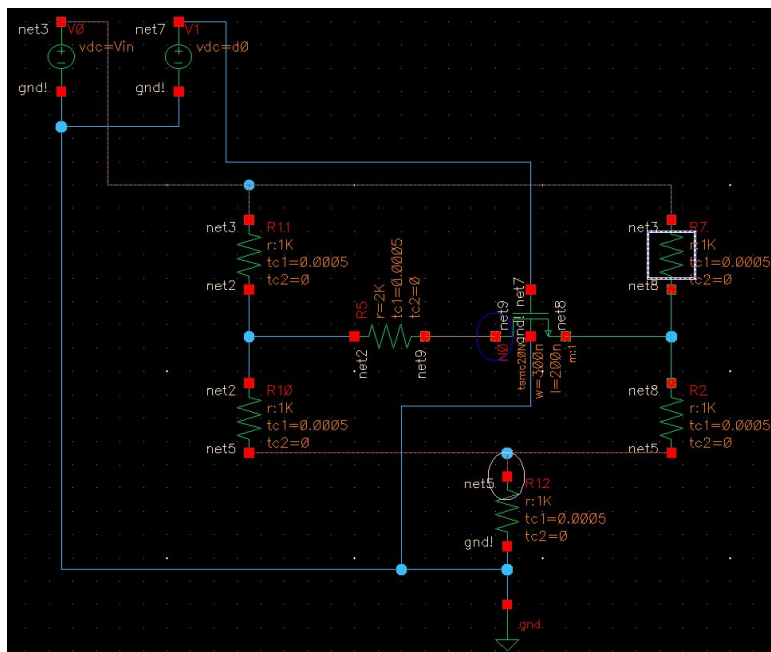
Oluwatosin Oyenekan:
- Transitioned to working online
- Set up remote desktop, figuring out how to get Virtuoso to work from my home computer
- Did some research on how to find the temperature coefficient of a circuit.
- Researched how the ladder structure would be able to trim a resistor and tried to understand the math behind it
- Didn't run any simulations myself, wanted to see the appropriate approach from my team members to finding temperature coefficient
- Completed weekly assignments for EE491

❖ **Pending issues**

Clark Reimers:
- Have had several issues nailing down precise temperature coefficients for our circuits. We still need to find an equation for resistance.

Pierce Nablo:
- All issues that were encountered over the past 4 weeks have been dealt with.

Alek Benson:
- No issues

Oluwatosin Oyenekan:
- No Issues

❖ **Individual contributions**

Name	Hours 3/16 - 3/29	Hours 3/30 - 4/12	Hours cumulative
Clark Reimers	12	10	72
Pierce Nablo	6	14	71
Alek Benson	13	12	72
Oluwatosin Oyenekan	7	10	65

❖ **Plans for the upcoming week**

Clark Reimers: Moving forward, we need to continue with the goal of defining a precise temperature coefficient for the current schematics that we have. For this, we need to define equations for resistances and the TCR equations. We also need to continue with expanding to larger structures and do some research on whether or not the temperature coefficient is constant. We also need to fully understand how our simulation environment is working so that there is no ambiguity in our testing.

Alek Benson: The plan is to finally fix the model for temperature coefficient of resistance, and find a way to correctly input this into Cadence. Once this is done, I can spend time re-running simulations of the series structure. I will also spend time simulating the ladder resistor structure and document my findings about it. I plan to spend some time modifying the schematics of the ladder structure to understand the trimming capabilities better.

Oluwatosin Oyenekan: The plan for this week is to begin simulating circuits to aid find the coefficient. the design ideas we came up with and present it to Gieger. My goal for this period is to test out and get a positive result from at least one circuit.

Pierce Nablo: For the next week, I want to dig into a physics textbook in order to figure out the definition of resistivity to help me understand why the simulation environment is behaving the way it. Then I will need to figure out what SPECTER needs from me in order to get the temperature coefficient to be a constant.

❖ **Summary of weekly advisor meeting**

We had numerous meetings with our academic advisor these past two periods for senior design. Our initial meeting was fine, as we updated the advisor with our move to online schooling as well as working on migrating to online methods to continue with our project. We talked about the next steps of the project and the need to examine the data and understand that Cadence simulations are ideal models and more tuning of the software is required to fit the simulation to our realistic model. We continued to update him for a couple of weeks every couple of days and tried to find what Cadence uses for temperature coefficient modeling. During the next period, we spent time trying to find the true model for temperature coefficient because it is a non constant property despite many resources listing it as a constant value. Our advisor is adamant about fixing this issue before continuing with more advanced simulations. The meetings for this period weren't great, but we have a direction to head in.