EE/CprE/SE 492 WEEKLY REPORT 03

9/14/2020 – 9/28/2020

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

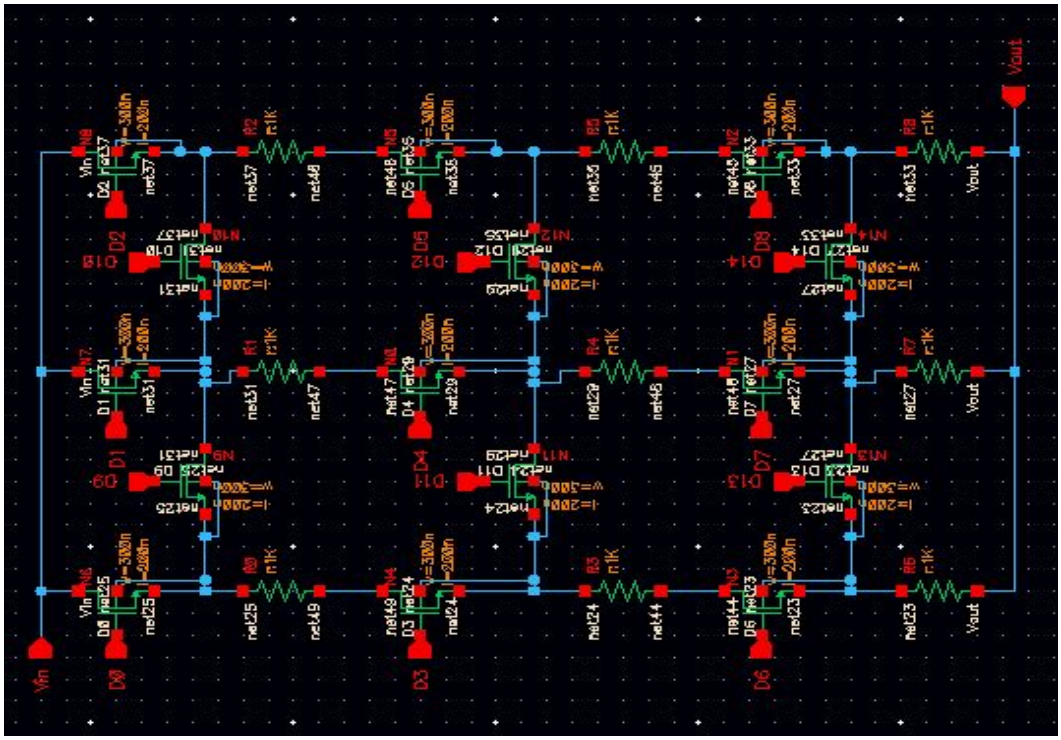
During the past 2 weeks our group has been working on more simulations of current designs. We also spent time brainstorming and drafting some new potential designs to compare to the references. A truss design and pyramid design architectures were drafted up. We also spent time determining basic standardized components for comparison. We selected a 10k ohm base resistor using 300n x 200n sized transistors. The resistor components will use a TCR of 1500 ppm/°C, and we will be comparing using 2-bit versions of each design. Once we find the best design using these parameters, we can scale up the final design to a 4-bit binary weighted trim with larger size transistors.

❖ Past week accomplishments

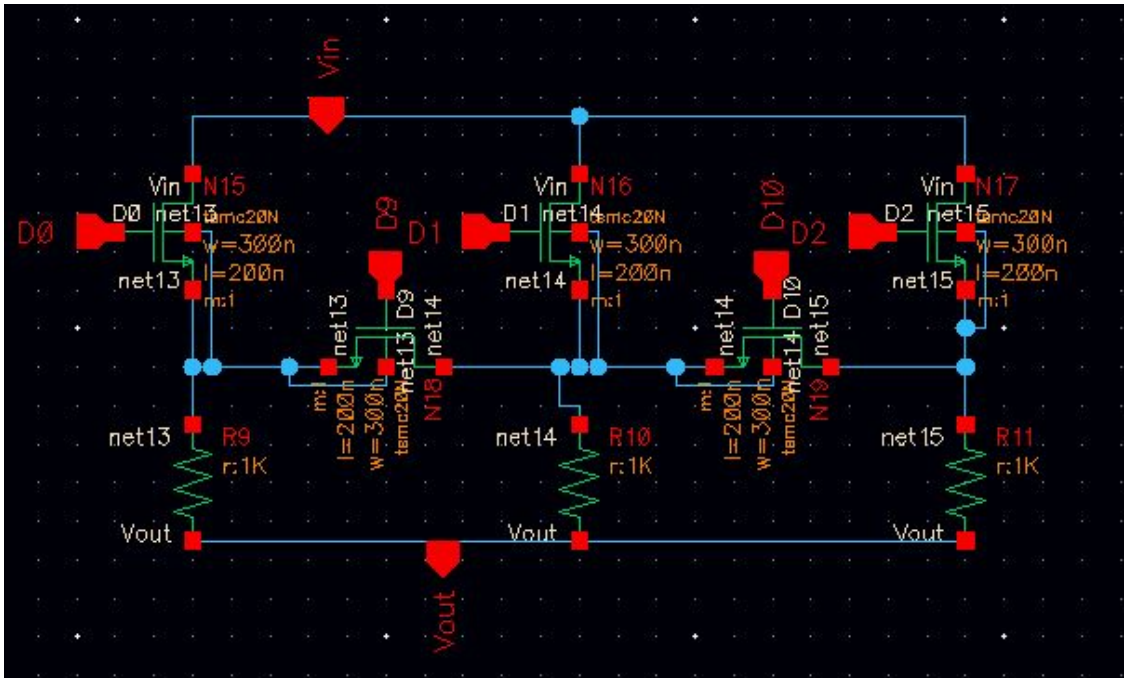
Clark Reimers:

- Finalized work on Voltage divider structure
    - Compared architecture to reference design
        - Discarded design as it pales in comparison to reference design
- Started work on the Matrix structure we developed in semester 1
    - Restricted to bit-level
    - Built testbench
    - Calculated the TCV to compare to reference designs.
- Started design on a new structure
    - Started work on 1 bit design
- Updated website
- Career fair

Matrix structure:



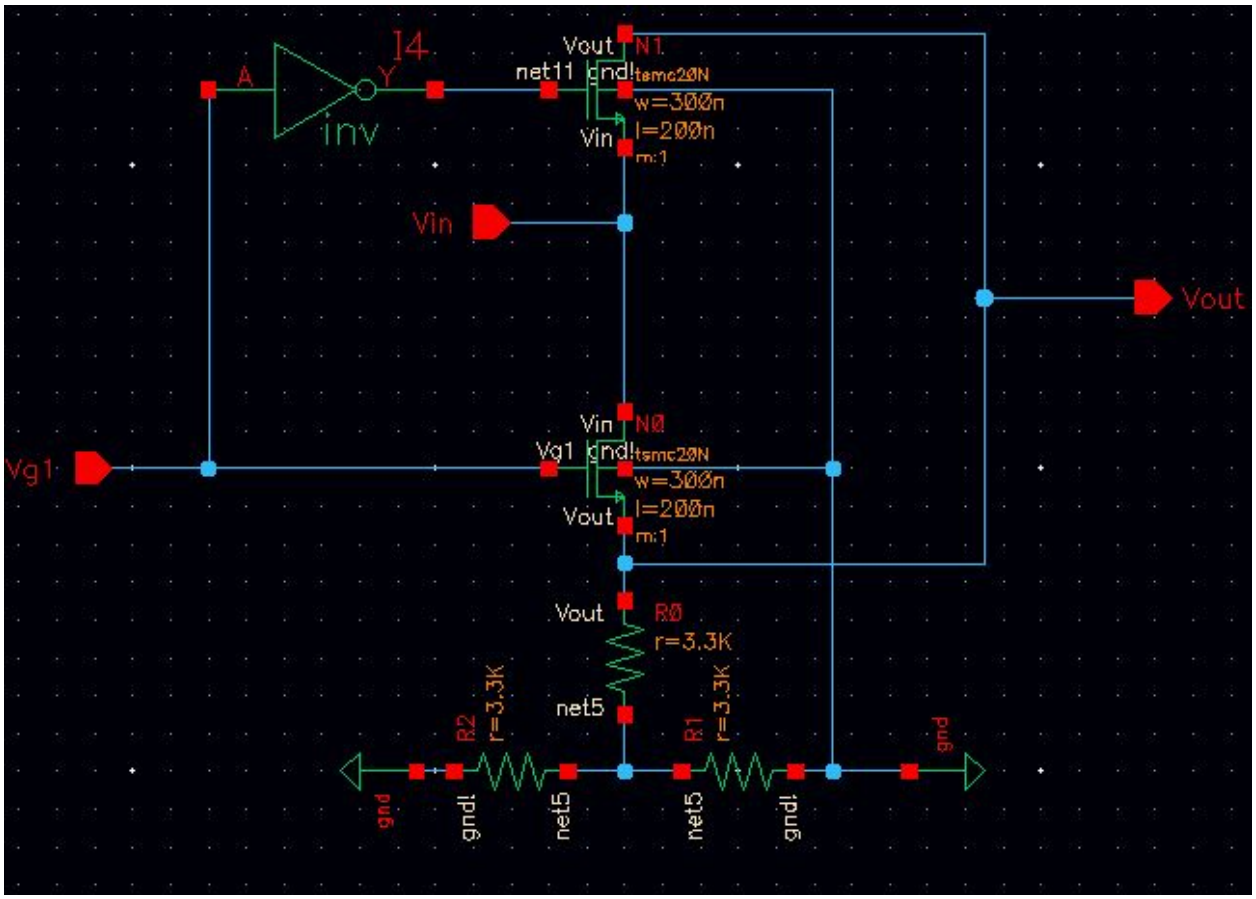
Updated structure:



Matrix Design Data:

	Assume open unless otherwise stated							
All switches closed								
Temp	Vdd	Vout	Current	R	TCV	TCR		
27	1	0.5568312965	0.000556831296	795.88	-1,976.91	4,465.25	-0.001100802607	-1976.905059
27.5	1	0.5562808952	0.000556280895	797.65				
Verticals closed								
Temp	Vdd	Vout	Current	R	TCV	TCR		
27	1	0.5568312965	0.000556831296	795.88	-988.45	2,232.63	-0.000550401303	-988.4525296
28	1	0.5562808952	0.000556280895	797.65				
Horizontals								
Temp	Vdd	Vout	Current	R	TCV	TCR		
27	1	9.98E-09	9.98E-12	100,194,265,326	33,032.94	-31,976.66	3.30E-10	3.30E+04
28	1	1.03E-08	1.03E-11	96,990,387,562.5				
110 Horizontals Closed								
Temp	Vdd	Vout	Current	R	TCV	TCR		
27	1	4.52E-01	4.52E-04	1,213.93	-1,177.86	2,150.68	-5.32E-04	-1.18E+03
28	1	4.51E-01	4.51E-04	1,216.55				
101 Horizontals Closed								
Temp	Vdd	Vout	Current	R	TCV	TCR		
27	1	4.52E-01	4.52E-04	1,213.93	-1,177.86	2,150.68	-5.32E-04	-1.18E+03
28	1	4.51E-01	4.51E-04	1,216.55				

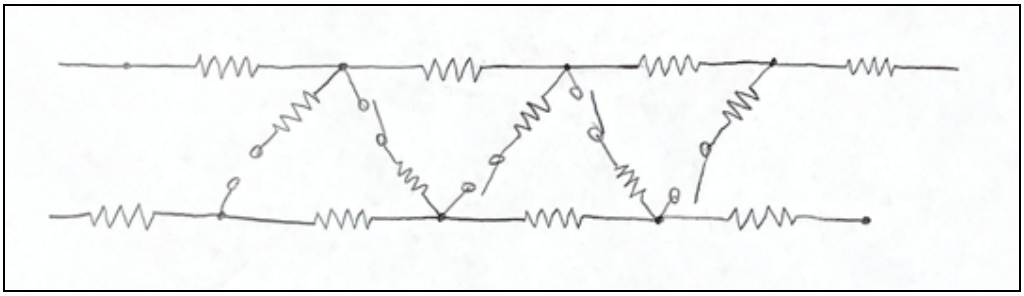
T-Branch Structure:



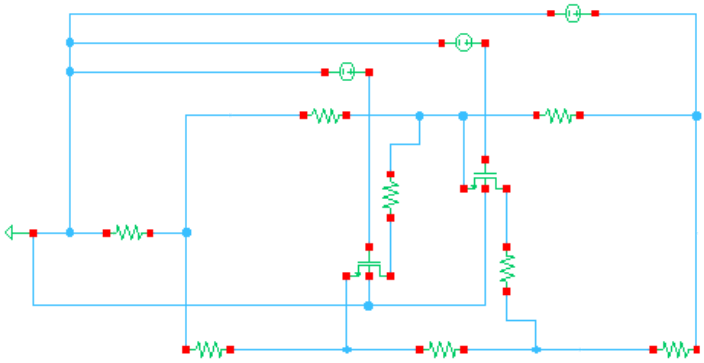
Pierce Nablo:

- Brainstormed a couple new designs which I have shown below. They are called the Resistor Truss, and Resistor Pyramid.
- Simulated the Resistor Truss.
- Began to dial in a 1% trim for the ladder design.
- Began to change the switch width to get a better TCV.

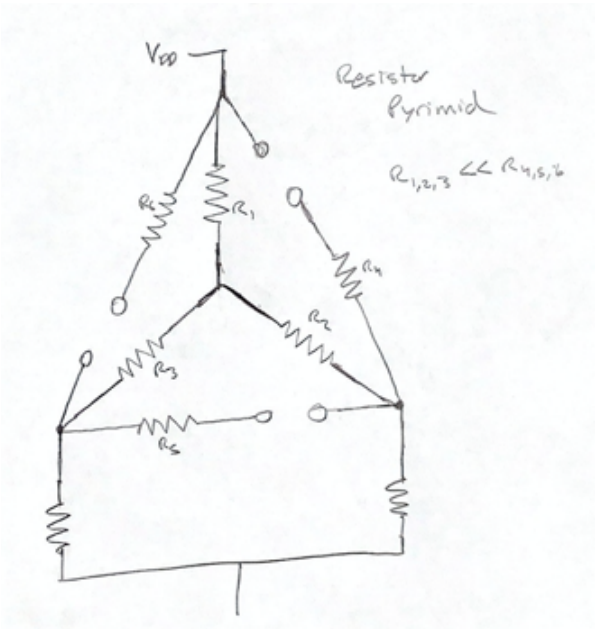
Resistor Truss Design



switch config	Temp	Vout	Iout	R	TCR	TCV			
off	27	0.4526748971	0.000452674897	1,209.090909183	1499.999838	-8.203E+02		905, 1050, min,	1K
off	28	0.4523035615	0.000452303561	1,210.904545353					
									-15 ohm trim
switch config	Temp	Vout	Iout	R	TCR	TCV			
On, off	27	0.4554008336	0.000455400833	1195.867741600	1500.783422	-816.6579254		905, 1050, min,	1K
On, off	28	0.4550289269	0.000455028926	1197.662480081					
									-30 ohm trim
switch config	Temp	Vout	Iout	R	TCR	TCV			
On, on	27	0.4601728984	0.000460172898	1173.096250294	1502.372384	-810.3641073		905, 1050, min,	1K
On, on	28	0.4597999908	0.000459799990	1174.858677704					
switch config	Temp	Vout	Iout	R	TCR	TCV			
off	27	0.4526748971	0.000452674897	1,209.090909183	1499.999838	-8.203E+02		905, 1050, min,	5K
off	28	0.4523035615	0.000452303561	1,210.904545353					
									-6
switch config	Temp	Vout	Iout	R	TCR	TCV			
On, off	27	0.4538560577	0.000453856057	1,203.341749073	1500.151679	-8.186E+02		45K, 55K, W3u,	1K
On, off	28	0.4534845184	0.000453484518	1,205.146944213					
									-12
switch config	Temp	Vout	Iout	R	TCR	TCV			
On, on	27	0.4553550274	0.000455355027	1196.088633763	1500.322019	-816.4756676		905, 1050, min,	1K
On, on	28	0.4549832411	0.000454983241	1197.883151876					
switch config	Temp	Vout	Iout	R	TCR	TCV			
off	27	0.4526748971	0.000452674897	1,209.090909183	1499.999838	-8.203E+02		905, 1050, min,	100
off	28	0.4523035615	0.000452303561	1,210.904545353					
									100 ohm trim
switch config	Temp	Vout	Iout	R	TCR	TCV			
on	27	0.456530319	0.000456530319	1,190.44	1501.56784	-8.154E+02		905, 1050, min,	100
on	28	0.4561580682	0.000456158068	1,192.22					
									150
switch config	Temp	Vout	Iout	R	TCR	TCV			
On, on	27	0.4651848669	0.000465184866	1149.682999500	1506.711568	-805.1633375		905, 1050, min,	100
On, on	28	0.4648103171	0.000464810317	1151.415240176					



Resistor Pyramid



Switch Width testing

switch config	Temp	Vout	Iout	R	TCR	TCV			
off	27	5.00E-01	1.00E-05	50,000.0000000000	1001.001001	0.000E+00		45K, 55K, W3u, .5K	
off	28	5.00E-01	9.99E-06	50,050.0500500501					
									-250 ohm trim
switch config	Temp	Vout	Iout	R	TCR	TCV			
On	27.0000000	0.5024756704	1.00E-05	49752.43296000000	-0.05647964996	0.05592310563		45K, 55K, W3u, .5K	
On	28.0000000	0.5024756985	1.00E-05	49752.43015000000					
switch config	Temp	Vout	Iout	R	TCR	TCV			
off	27	0.4999999999	1.00E-05	50,000.0000100000	1001.001201	-2.000E-04		45K, 55K, W3u, 1K	
off	28	0.4999999998	9.99E-06	50,050.0500700701					
									-250
switch config	Temp	Vout	Iout	R	TCR	TCV			
on	27	0.5024513949	0.00001000000	49,754.86051000000	-0.05527098185	5.473E-02		45K, 55K, W3u, 1K	
on	28	0.5024514224	0.00001000000	49,754.85776000000					
switch config	Temp	Vout	Iout	R	TCR	TCV			
off	27	0.4999999999	1.00E-05	50,000.0000100000	1001.001201	-2.000E-04		45K, 55K, W30u, 5K	
off	28	0.4999999998	9.99E-06	50,050.0500700701					
									-230
switch config	Temp	Vout	Iout	R	TCR	TCV			
on	27	0.5022819828	1.00E-05	49,771.80	-0.00642934328	6.371E-03		45K, 55K, W30u, 5K	
on	28	0.502281986	1.00E-05	49,771.80					

Alek Benson:

- Re-configured series structure to meet standardized comparison parameters.
- Re-configured ladder structure to meet standardized comparison parameters.
- Simulated, and documented data on both of the structures. Compared TCV values to the other structure versions.
- Documented standardization parameters.
- Met with advisor, and planned on switching designs to binary weighted design with larger transistors.
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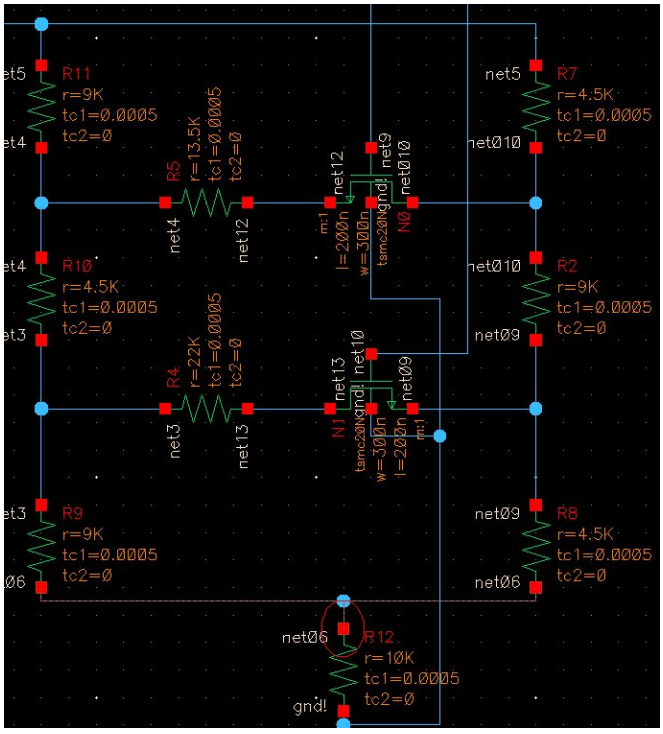
NO BITS	Bit 0 ON	Bits ON
TCV	TCV	TCV
1.16818E-06	-4.22617	-8.44916
in ppm/°C		
27 to 28°C		

- 

Oluwatosin Oyenekan:

- Did some research on how to find the temperature coefficient of a circuit and was confused until meeting with dr geiger who cleared it up.
- Brainstormed on some new circuit designs we can use, currently thinking on mixing two of our already existing designs together,

❖ **Pending issues**

Clark Reimers:

- No issues

Pierce Nablo:

- No issues

Alek Benson:

- No Issues

Oluwatosin Oyenekan:

- No Issues

❖ **Individual contributions**

Name	**Hours 9/14 - 9/21**	**Hours 9/22 - 9/28**	**Hours cumulative**
Clark Reimers	3	8	42
Pierce Nablo	3	8	43
Alek Benson	3	8	43
Oluwatosin Oyenekan	3	6	39

- **Plans for the upcoming week**

  Clark Reimers: Continue working on testing the matrix design as well as my new design. Need to establish the 1% trimmability and compare TCV to the reference design to determine eligibility.

  Alek Benson: The plan for the upcoming week is to work on drafting up some new designs with the team so that we can start simulating and comparing the designs. I plan to reconfigure the ladder structure again because the trim size was wrong last week. Also we need to start comparing data using our standardization, so that we can find the final design.

  Oluwatosin Oyenekan: My Plan for this coming week is to finalize a design and simulate it on virtuoso. I would also compare the results with that of our previous designs

  Pierce Nablo: I will finalize the resistor truss design so it is comparable to other designs we make. des

- **Summary of weekly advisor meeting**

  We presented a few new designs to Geiger in order to try and beat the performance of the ladder structure. A couple of the designs were the matrix design, the resistor truss, and the resistor pyramid designs. During the meeting we determined that we are going to need to come up with a standardized format inorder to compare our various designs. We determined that the format should keep constant: 2 bit trimming, 10,000 ohm total resistance, total trim will equal 1% of 10,000 ohms, and switch sizes will be constant.