

---

## **EE/CprE/SE 492 WEEKLY REPORT 05**

**10/13/2020 – 10/26/2020**

**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**

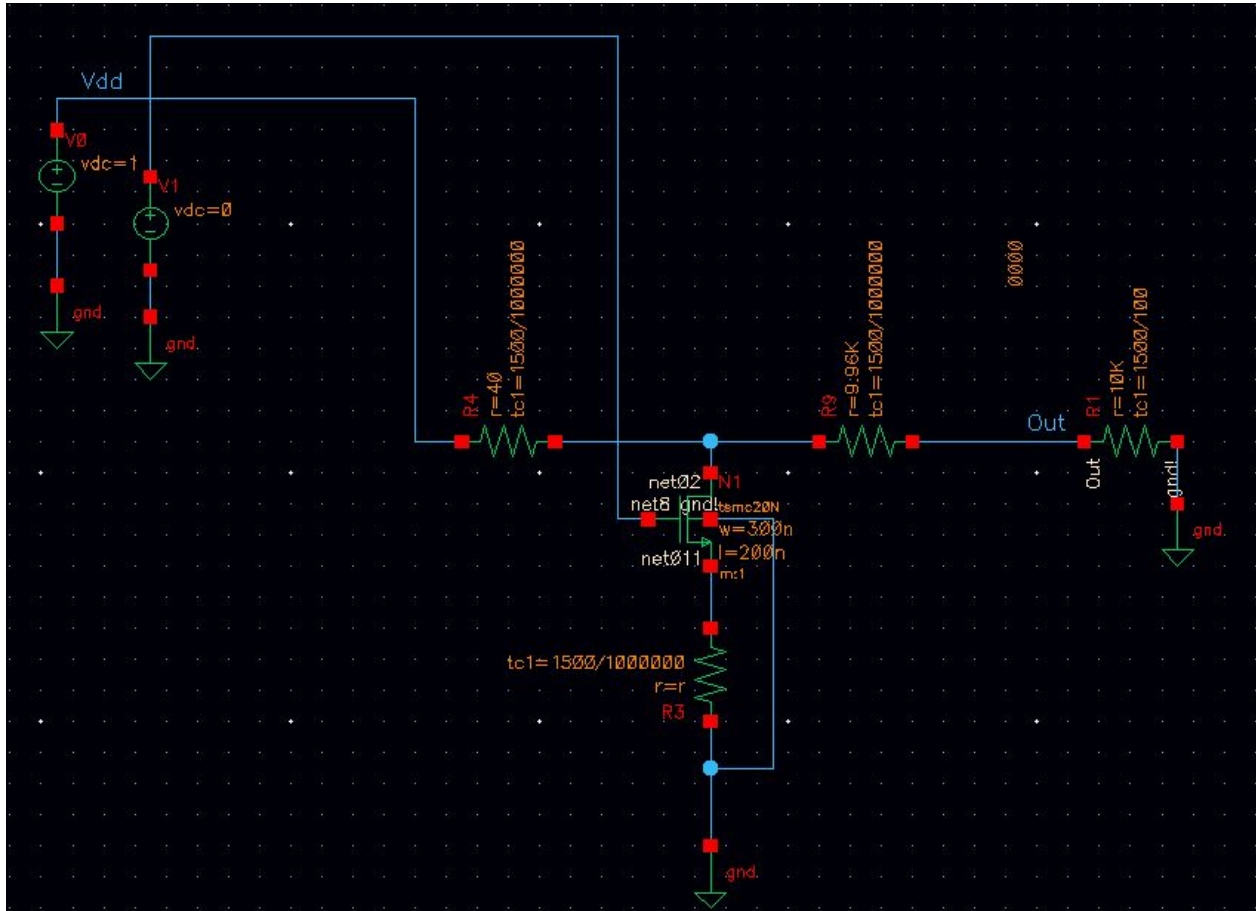
During the past 2 weeks our group has been working mainly on getting a binary weighted trim format for our resistor structure designs. We were able to get the thermometer weighted versions to work fine, but the binary weighted versions require much more fine tuning of resistor values. We spent a lot of time trying to get the binary versions working, but we were not able to get them to work yet. We discussed this with our advisor who thought that it would be best if we look at using an analytical approach to finding the correct values for our resistors. The next step is to model the equivalent resistance equations in MATLAB and solve for our desired trimming levels by iterating through various parameter settings.

### ❖ **Past week accomplishments**

Clark Reimers:

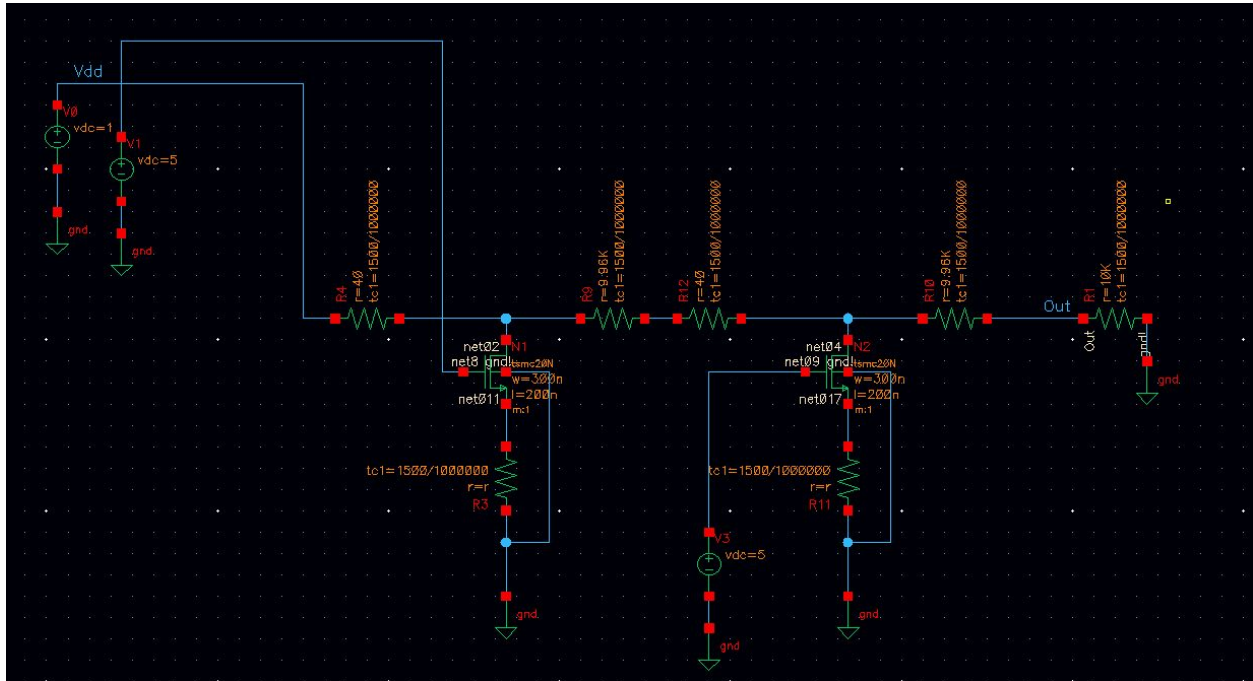
- Continued working on improvements to the voltage divider structure
  - Got 1 bit to work
    - TCV took a slight hit but is still good
- Trying to expand to 2-bits while maintaining binary weight and 1% trim is challenging and in process
  - May need to discard the structure
- Did more research to see if I could find something else to reduce TCV
- Worked on PIRM with the team as well as some other administrative tasks
- Updated website

### Voltage Divider (1 bit):



0	1 bit VD @10k									
1										
2	off									
3	Temp	Vdd	Vout	Current	R	TCV	TCR			
4		27	1	0.4999999999	5.00E-05	10,000.00	-0.00000460	1,500.00	0 -0.000004596101	
5		28	1	0.4999999999	4.99E-05	10,015.00				
6										
7	on									
8	Temp	Vdd	Vout	Current	R	TCV	TCR			
9		27	1	0.4987532242	4.99E-05	10,050.00	0.05674607	1,499.89	0.000000028302; 0.05674607128	
0		28	1	0.4987532525	4.98E-05	10,065.07				
1										
2										
3		Res	% trim	all off						
4	on	10,000.00	0.000%	10000						
5	off	10,050.00	0.500%	10000						

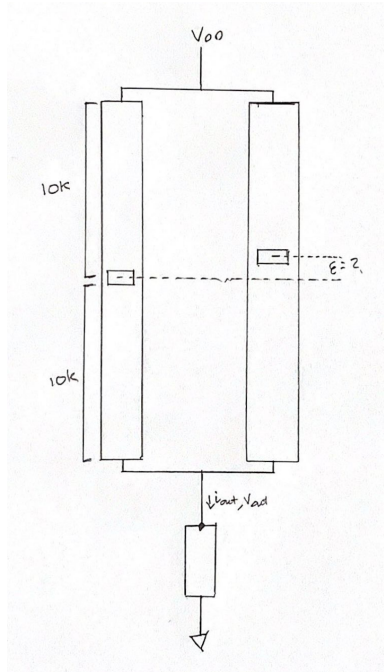
## Voltage divider (2-bit):



2 bit VD with R ~ = 10K									
VD 2 bit both on									
Temp	Vdd	Vout	Current	R	TCV	TCR			
27	1	0.2339544029	2.34E-05	32,743.37	1.31663873	1,498.28	0.000000308033		1.316638735
28	1	0.2339547109	2.34E-05	32,792.43					
VD first bit on (second off)									
Temp	Vdd	Vout	Current	R	TCV	TCR			
27	1	0.3325015958	3.33E-05	20,075.04	0.05595132	1,499.92	0.000000186031		0.05595132236
28	1	0.3325016144	3.32E-05	20,105.15					
VD second bit on (first off)									
Temp	Vdd	Vout	Current	R	TCV	TCR			
27	1	0.2345401114	2.35E-05	32,636.63	1.27019327	1,498.34	0.000000297911		1.270193274
28	1	0.2345404093	2.34E-05	32,685.53					
VD both bits off									
Temp	Vdd	Vout	Current	R	TCV	TCR			
27	1	0.3333333251	3.33E-05	20,000.00	-0.00090260	1,500.00	-0.00000000030C		-0.000902595021
28	1	0.3333333248	3.33E-05	20,030.00					
	Res	% trim	all off						
VD 2 bit both on	32,743.37	63.717%	20,000.00						
VD first bit on (second off)	20,075.04	0.375%	20,000.00						
VD second bit on (first off)	32,636.63	63.183%	20,000.00						
VD both bits off	20,000.00	0.000%	20,000.00						

Pierce Nablo:

- I attempted to get a ¼ % trim but ran into an issue which the pictures below show. The issue is that I cannot get my circuit to go between .29% and .09% trim. I am going to try and make the switch more ideal to see if that fixes the problem.
- Started to make a MATLAB script to help find the resistor values that we need in order to get a ½ %, ¼ % trim in our circuit.



TCR	TCV	Trim	9105, 10895
1999.992177	0.007792195	29.96	epsilon = 895
TCR	TCV	Trim	9106, 10894
-0.00760760252	0.007592412	9.99	epsilon = 894

Alek Benson:

- Worked on ladder structure to try to achieve a binary weight, and was able to achieve a rough binary trim. This was clearly not optimal and came at a cost.

Simulate				Calculate		Performance		
State	Temp	V	I	Resistance	Trim	TCR	TCV	% Trim
OFF OFF	27.00	0.4999999999	0.0000500000	10,000.00	0.00	1500.0000	0.0000	0.00%
OFF OFF	28.00	0.4999999998	0.00004992511	10,015.00				
ON OFF	27.00	0.50170167795	0.00005017017	9,932.16	67.84	1513.0092	-6.4727	0.68%
ON OFF	28.00	0.50169843058	0.00005009470	9,947.19				
OFF ON	27.00	0.50090069947	0.00005009007	9,964.04	35.96	1500.0150	-0.0075	0.36%
OFF ON	28.00	0.50090069573	0.00005001505	9,978.98				
ON ON	27.00	0.50239070576	0.00005023907	9,904.83	95.17	1500.6483	-0.3221	0.95%
ON ON	28.00	0.50239054394	0.00005016381	9,919.69				

- Created a Binary Structure that tripled the total resistance value of the resistor structure.
- Worked with the team to discuss moving forward with resistor structures.
- Decided to continue optimizing the ladder structure using an analytical approach using MATLAB.

Oluwatosin Oyekan:

- Simulated the truss design but my results weren't up to par
- Researched on ways we could reduce the TCV and how we can increase the bits in our designs
- Worked on the prim with my group members
- Listened to my other team members solution on their simulations to fix my results

❖ **Pending issues**

Clark Reimers:

- No pending issues.

Pierce Nablo:

- No issues at the moment

Alek Benson:

- No Issues

Oluwatosin Oyekan:

- No Issues

❖ **Individual contributions**

<b><u>Name</u></b>	<b><u>Hours 10/13 - 10/20</u></b>	<b><u>Hours 10/20 - 10/26</u></b>	<b><u>Hours cumulative</u></b>
Clark Reimers	4	10	70
Pierce Nablo	2	6	65
Alek Benson	5	7	69
Oluwatosin Oyekan	6	6	62

❖ **Plans for the upcoming week**

Clark Reimers: Continue trying to expand to 2 bit structure of the voltage divider while maintaining a 1% binary trim. Perhaps start looking at a new structure as well or focus attention on the ladder structure. Start working on cleaning up work and organizing documentation.

Alek Benson: The plan is to continue optimizing the binary weighting for the ladder structure. We are planning on working through the problem using an analytical approach using MATLAB.

Oluwatosin Oyekan: My Plan for this coming week is to help on the creating the ladder structure with 4 bit and also help on creating the matlab script.

Pierce Nablo: I will be working on making a MATLAB script to help automate finding the  $\frac{1}{2}$  %,  $\frac{1}{4}$  % trim resistor ratios.

❖ **Summary of weekly advisor meeting**

Our advisor meeting went quick this past week. We showed our advisor Dr. Geiger, what we have been working on. He seemed to be on board with the majority of what we were doing and advised us to maybe make a MATLAB script to automate finding the resistor values for the Ladder Structure.