Lab 6: Selection of proper trace width **- Rishab Shah**

A) Calculation of Sheet resistance:

Width(W)	cm	mm	Mil(L)	Squares(L/W)	R (mohm)	Resistance (m Ohm)
6	2.5	25	984.252	164.042	0.5	82.02099738
8	2.5	25	984.252	123.0315	0.5	61.51574803
10	2.5	25	984.252	98.4252	0.5	49.21259843
20	2.5	25	984.252	49.2126	0.5	24.60629921
100	2.5	25	984.252	9.84252	0.5	4.921259843
393.7007874	10	100	3937.008	10	0.5	5

The above table was calculated in a spreadsheet. The length (L) of the trace was measured using the ruler provided. The width (W) of the trace was known. Number of squares are calculated using L/W as shown in the table above. There was no 8-mil width trace on the given board. Hence, marked in red.

The sheet resistance of 5 mOhm was chosen as per below calculation:

For 1 oz copper, the sheet resistance is

$$R_{sq} = \frac{\rho}{t} = \frac{1.7 \times 10^{-8}\ \Omega - m}{34\ um} = 0.5\ m\Omega$$

B) Two-wire and 4-wire comparative analysis:

A average value of resistance was to fill up the following table:

Line width	Estimate	2-wire (m Ohm)	4-wire with 1 A current
6 mil	82.02099738	160	63.7275
8 mil	61.51574803	Trace absent	Trace absent
10 mil	49.21259843	135	34.375
20 mil	24.60629921	117.5	16.5775
100 mil	4.921259843	100	3.605

To calculate resistance, we use Ohm's Law. Ohm's law considers that for the given ideal voltage, ideal current is flowing. But that does not happen in case of very low resistance. In case of 2-wire method for low resistance, the current flowing is too large (it is as good as a short circuit) Hence, the measured value is incorrect.
The 4-wire method ensures that the current flowing through the trace is constant as supplied. Hence, Any voltage visible is the actual drop between the end points of the flow. Thus, we get accurate measurement in case of 4-wire method.

There is slight variation in measurement because the given copper may not be 1 Oz or thickness may not be 34um for the trace. However, it is very close to the theoretical measurements. For measurements, sample 1 = top-right, sampe-2 is top-left, sample-03 is bottom left and sample-4 is bottom-right to ensure that there is uniformity in trace length while taking measurement.

Following is the detailed measurement procedure:

	Width	6 mil				R (m Ohm)
Method	4-wire	Sample 1	Sample 2	Sample 3	Sample 4	
	V (mV)	64.85	64.56	60.19	65.31	
	I	1	1	1	1	
	R	64.85	64.56	60.19	65.31	63.7275
		1	2	3	4	
Method	2-wire	0.16	0.16	0.16	0.16	160

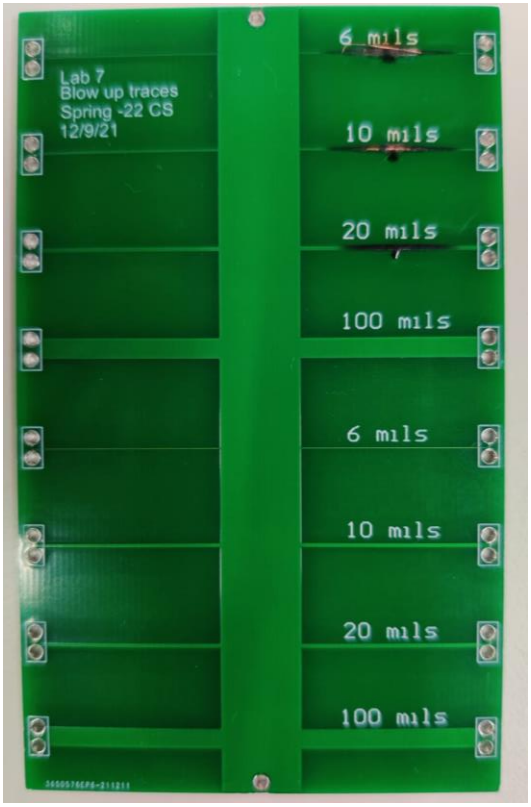
	Width	10 mil				R (m Ohm)
Method	4-wire	Sample 1	Sample 2	Sample 3	Sample 4	
	V (mV)	34.78	33.97	Trace absent	Trace absent	
	I	1	1			
	R	34.78	33.97			34.375
		1	2			
Method	2-wire	0.13	0.14			135

	Width	20 mil				R (m Ohm)
Method	4-wire	Sample 1	Sample 2	Sample 3	Sample 4	
	V (mV)	16.6	16.19	16.32	17.2	
	I	1	1	1	1	
	R	16.6	16.19	16.32	17.2	16.5775
		1	2	3	4	
Method	2-wire	0.11	0.12	0.12	0.12	117.5

	Width	100 mil				R (m Ohm)
Method	4-wire	Sample 1	Sample 2	Sample 3	Sample 4	
	V (mV)	3.55	3.44	3.63	3.8	
	I	1	1	1	1	
	R	3.55	3.44	3.63	3.8	3.605
		1	2	3	4	
Method	2-wire	0.1	0.1	0.1	0.1	100

C) Blow up traces:

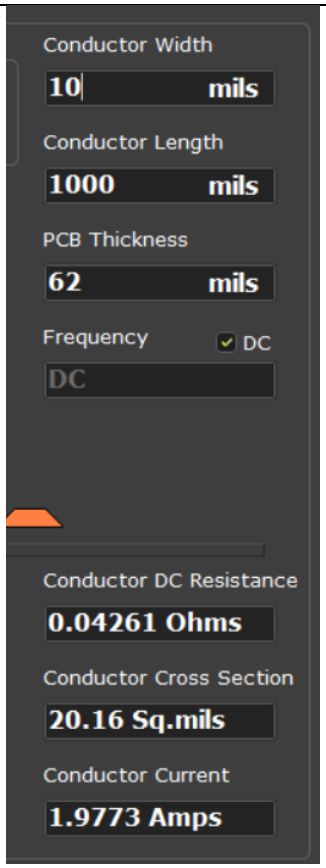
The current through the CC power supply was increased gradually to find the following breaking-point current. These are usually perspective based and can vary from person to person and environment.
I would consider the breaking point is usually **3x** (smoke/estimate) the value estimated using Saturn tool.

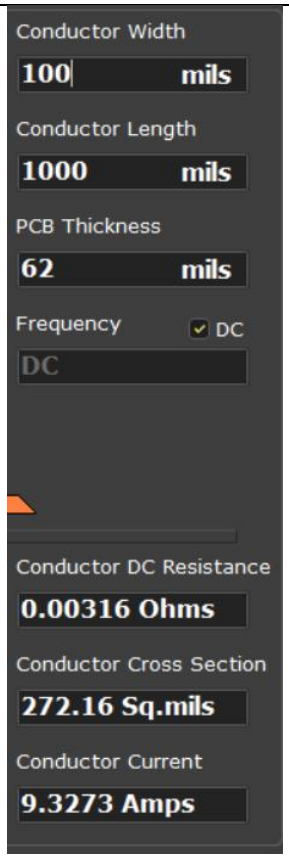


Width (mil)	Estimate (Safe Margin)	Warm (A)	Hot (A)	Smoke (A)	Ratio
6	1.2195	2.5	3.5	4.5	3.6900369
10	1.9773	3.4	4.75	6.5	3.28731098
20	3.3226	6.5	7.5	10	3.009691206
100	9.32733	NA	NA	NA	

Due to limitations of the CC powers supply to provide 10 A current as maximum, the 100-mil width trace could not be tested as current about 30 A or more would be required to cause a smoke as well as due to large width there is large space to cool down. Hence, the time taken would also be huge. The 3x-4x ratio might not work for this case.

D) Saturn tool screenshots:





E) ***Conclusion/ Learnings:***

1. One should make use of 4-wire method when trying to measure very small resistance.
2. Learnt how to use a CC power supply.
3. Even though 6-ml width trace can handle about 2A current without any heat up, it is better to use a 20-mil width for power line identification purpose and reduce errors.
4. There is no change from CV to CC. It always remains in CC mode because the current flowing through the traces is very large (greater than 10 A) at any point of measurement. However, when 1K resistance was connected across the CC power supply, it displayed CV mode as the current to be supplied was well within the required 1A.
5. Learnt to estimate the max. current using Saturn tool.