Practical PCB Design and Manufacture

Lab-11 and Lab-12 Report: Trace resistance and Blow-Up Resistance

Objective / Purpose of the Lab:

- The main goal of Lab 11 is to use both 2-wire and 4-wire measurement techniques to evaluate the resistance of different traces with varying lengths. This is being done to investigate how trace resistance affects the overall performance of the circuit. On the other hand, Lab 12 is concerned with figuring out the highest amount of safe current that may be applied to a trace. After then, it seeks to gradually raise the current above the safe limit until the traces fail, which is indicated by overheating, a black discoloration, and a light smoke emission.

Component Listing:

- Blow up trace board.
- Power supply
- Digital multi-meter
- Wires for measuring
- Banana to mini grabber cables

Calculations:

The resistance of the trace is calculated using the formula given below:

Resistivity (Ω/m)

$$R = \frac{\rho\, l}{A}$$

Length of wire (m)

Resistance (Ω)

Cross sectional area of wire (mm^2)

Now, for 1oz copper, the sheet resistance is calculated as follows:

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

For the case of a 6-mills wide trace length, the resistance per inch is, the length of the trace will always be constant i.e., 1 inch.

For 6 mills, R = (1 inch/6 mills) x 0.5 mΩ	**Thus, R = 83.3mΩ**
For 10 mills, R = (1 inch/10 mills) x 0.5 mΩ	**Thus, R = 50mΩ**
For 20 mills, R = (1 inch/20 mills) x 0.5 mΩ	**Thus, R = 25mΩ**
For 100 mills, R = (1 inch/100 mills) x 0.5 mΩ	**Thus, R = 5mΩ**

Board Layout:

With mirrored layouts on both sides, the experimental board is a dual-layered design that offers four different sets of traces in different sizes for experimental examination. A long, wide strip with two touch points at either end is in the center of the board. In addition, there are two contact pads at either end of the test lines that are one inch long. For the objectives of the experiment, the resistance of these traces is assessed using both 2-wire and 4-wire testing approaches.

The mentioned PCB, which has tracks with different widths of 6, 10, 20, and 100 mils and a length of one inch, is used for the experiment. A PCB's copper sheet resistance is measured in milliohms (mΩ).

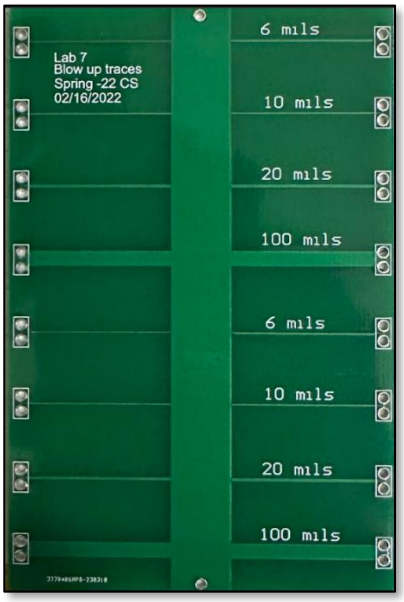

Fig – 1: Board layout

Measurements:

The table given below compares the values of the resistances that are calculated, and the ones measured using 2-wire and 4-wire method respectively.

Line Width	Estimated	2-Wire	4-Wire with 1A current
6 mil	0.083Ω	0.28Ω	0.0785Ω
10 mil	0.050Ω	0.22Ω	0.045Ω
20 mil	0.025Ω	0.18Ω	0.020Ω
100 mil	0.005Ω	0.15Ω	0.0038Ω

So, from the above table we can analyse that when measuring the resistance of traces on a PCB, both the 2-wire and 4-wire (Kelvin) methods can be used, but they differ significantly in their accuracy and the effects they account for, especially for traces of different widths such as 6, 10, 20, and 100 mils.

In 2-Wire Method, because wire and contact resistances are included in the measurement, this method is less accurate for all trace widths. When these extra resistances account for a greater percentage of the overall measured resistance, the effect is more pronounced for narrow traces.

For 4-Wire Method, by removing the impact of contact and wire resistances, this method yields precise measurements for all trace widths. To ensure that the measured value closely resembles the actual trace resistance, this method is especially important for precisely measuring the resistance of small traces.

Thus, the 4-wire approach is better at minimizing outside impacts on the measurement result. In summary, the choice of measurement method has a substantial impact on the accuracy of resistance measurements for PCB traces.

For Blow Up Traces, we calculate the maximum current for the 6 mil and 20 mil trace using the **Saturn PCB Tool.**

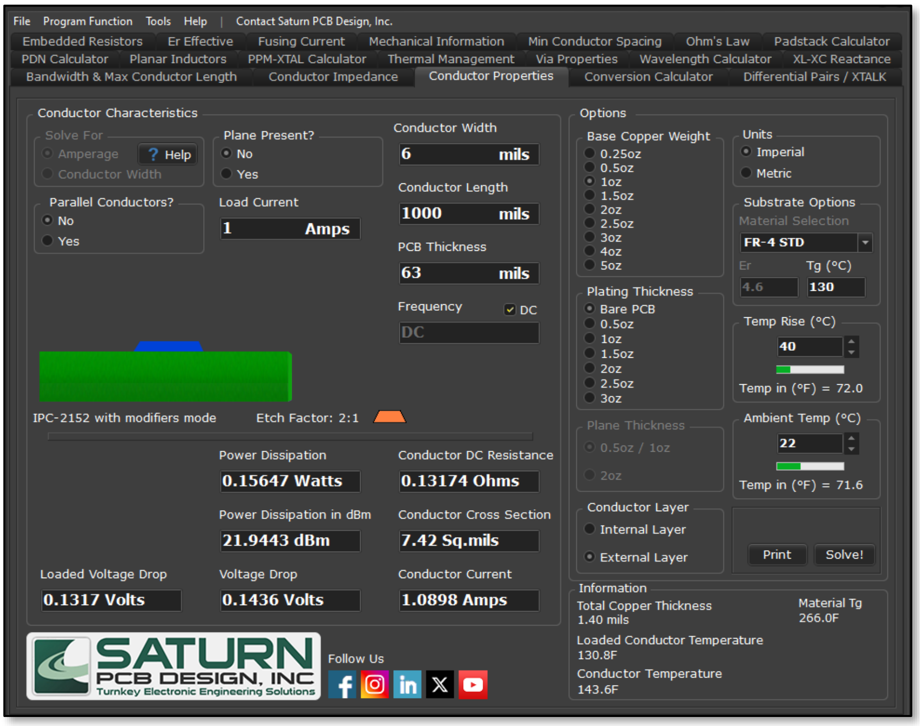

Fig – 2: Conductor Current as 1.0898 A for 6 mil trace

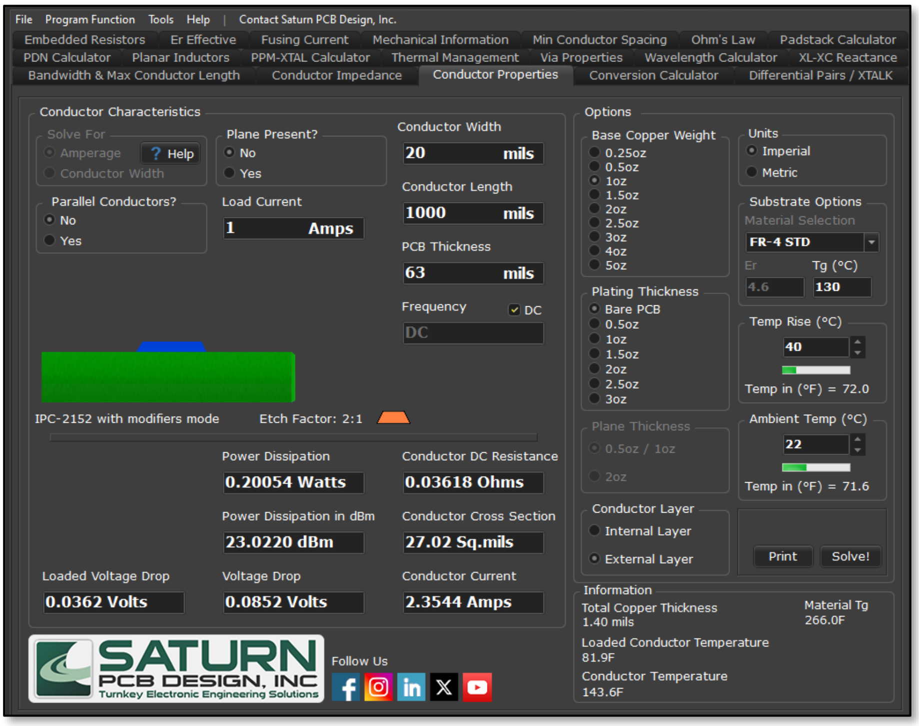

Fig – 3: Conductor Current as 2.3544 A for 20 mil trace

Measurements:

As we can see from the board given in Fig 4, the burnt traces along the 6 mills line and the 20 mills line.

Trace Condition	6 mil	20 mil
Warm	1 A	2.2 A
Hot	2.5 A	5.1 A
Smoke	4.2 A	8.2 A

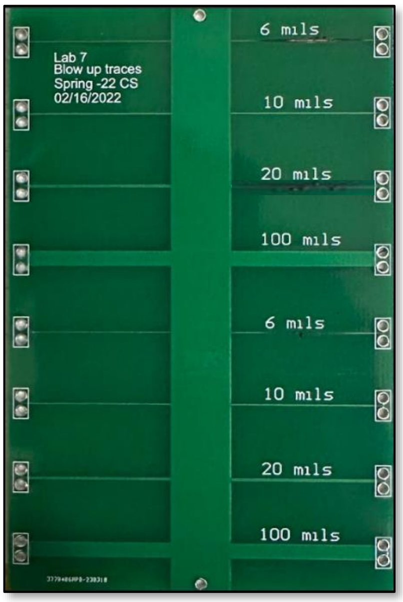

Fig – 4: Blown up traces on board

Thus, the capacity of a PCB to dissipate heat is directly correlated with the trace's width. In comparison to narrower traces, wider traces may carry more current and dissipate heat more effectively, resulting in lower temperatures at the same current settings. Due to their limited surface area, narrow traces are more likely to overheat because of their inability to dissipate heat as well. Because overheating can cause damage to electronic circuits, it is imperative that trace width and temperature are correlated for the durability and dependability of these circuits.

Conclusion / Inference:

- Prior to measuring, always estimate the trace resistance using Rule #9 (Before you do a measurement anticipate what you expect to see). The track width, length, and sheet resistance would all affect the trace resistance.
- The tolerances of the employed cables are the cause of the little discrepancy between the calculated and measured readings.
- Resistance in the trace decreases and current carrying capacity rises as the trace's width spreads. There is an inverse relationship between resistance and breadth.
- A thermal runaway happens when the trace's current threshold value is exceeded, at which point it functions as an open fuse.
- The trace's width and current carrying capacity are directly correlated.