Resistance of a copper trace: Rule of Thumb #14

Eric Bogatin - August 13, 2014

This rule of thumb is a quick and simple way of estimating the DC resistance of a copper trace on a board.

Spoiler summary: The resistance of a ½ ounce circuit board trace is 1mΩ/square × the number of squares down the length of the trace.

Remember: before you start using rules of thumb, be sure to read the Rule of Thumb #0: Use rules of thumb wisely.

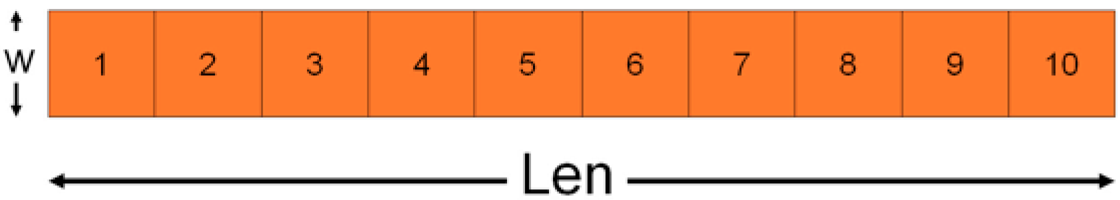
Previous: Rule of Thumb #13: Sheet resistance of copper foil

In the last rule of thumb, we introduced the sheet resistance of a copper foil. The edge to edge resistance of a section of copper foil, cut in the shape of a square, depends only on the thickness of the foil and the bulk resistivity of the copper.

For 1 ounce thick copper foil, we showed the sheet resistance is 0.5mΩ/sq. For ½ oz copper, it is 1mΩ/sq.

If we have a long, narrow trace on a circuit board etched from ½ oz thick copper foil, every square down its length will have an edge to edge resistance of 1mΩ. If we count up the number of squares in series, as illustrated below, we can quickly estimate the total resistance as being simply the number of squares times the sheet resistance:

$$R = n \times R_{sq} = \frac{Len}{w} \times R_{sq}$$



If the trace is 1 inch long and 0.1 inches wide, there are 1”/0.1” = 10 squares that can fit end to end down the line. Each square has a resistance of 1mΩ, so the total end to end resistance of the trace is

10 sq × 1mΩ = 10mΩ.

A trace in a package might be 2 mils wide and 500 mils long. There are 500/2 = 250 squares down its length. If it were built in ½ oz. copper, the DC resistance would be 250 × 1mΩ = 0.25Ω.

Generally, a package trace built in HDI (high-density interconnect) technology might even be ¼ oz copper, so the sheet resistance is twice ½ oz. copper, or 2mΩ/sq. The DC resistance of the above trace would be 250 sq × 2mΩ/sq = 0.50Ω.

Using this simple relationship makes calculating the series resistance of a copper trace trivial. We can almost estimate it by inspection. If you can estimate the number of squares and you know the foil thickness, you can estimate the series resistance.

Of course, this is the DC resistance. As we showed in Rule of Thumb #4, the cross sectional area through which the current travels in a trace decreases with frequency. At 1GHz, skin depth is only 2µm. In microstrip for example, current travels in both surfaces, so the current travels through only 4µm thickness, even though the geometrical thickness might be 16µm. This means that from DC to 1GHz, the resistance of a line might increase from 0.50Ω at DC to 16µm/4µm × 0.50Ω = 2Ω at 1 GHz.

Now you try it:

1. What is the DC resistance of a 0.5 ounce backplane trace, 40 inches long and 8 mils wide?
2. What is the DC resistance of a 1 ounce power lead that is 100 mils wide and 4 inches long. Is this a lot or a little?

Next rule of thumb #15: Estimating sheet inductance of a cavity.