Summary

It is sometimes necessary to know the DC resistance of a track, and its resistance can be calculated from the formula

$$R = \rho * L/A$$

where

R is the end-to-end track resistance in Ohms
ρ is the resistivity of the track material in Ohm Metres
L is the track length in metres
A is the track cross sectional area in square metres

according to the international MKS standard of units.

Track Resistance (R)

A material with a higher resistivity ρ (the intrinsic quality to resist the flow of electricity) will exhibit higher track resistance. Therefore

$$R \, \alpha \, \rho$$

A longer track length L will increase track resistance (electricity has to push its way through a longer path.) Therefore

$$R \, \alpha \, L$$

A larger track cross-section A will decrease the track resistance (larger cross section means that it is easier for the electricity to pass through.) Therefore

$$R \, \alpha \, 1/A$$

Resistance is therefore

$$R = K * \rho * L/A$$

where K is a constant. If we chose convenient units then K = 1, and the formula reduces to

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Resistivity, ρ (Rho)

What is ρ?
The resistivity ρ of the metal is a measure of its intrinsic ability to resist the flow of electricity, and in MKS units is the resistance in Ohms between the two end faces of a piece of the material which is one square metre in cross section and one metre in length, and is given in "Ohm Metres"

Sources will quote a variety of values for ρ. This is because the resistivity varies with material temperature, molecular structure (according to whether the material was electro-deposited, solidified from molten, rolled, annealed, etc.), impurity content, and more.

For the purpose of this discussion, we assume that your material suppliers can provide the resistivity specification for their copper, or other metal, at room or operating temperature. A likely MKS figure for ρ for copper will be in the region of 1.65E-8 Ohm Metres, or 0.0000000165 Ohm Metres.

Adjusting Rho to suit the measurement units you use
Confusion, terror and error often arise because some conversion of the MKS value for ρ is required to cope with the variety of units which are normally used in industry. Nobody measures track dimensions and areas in metres.

In Metric units, microns (sometimes called micrometres with the symbol um or mm) are more common for cross section dimensions. Track length is more normally in centimeters or millimeters (cm or mm)

In American units, even more confusion reigns when converting to thousandths of an inch (old name "mil", now the IPC standard is "thou" or "thousandth") for the cross section, and inches for the length. Knowing that one metre is approximately 39.37 inches, you can derive a value of ρ which takes into account the units of your choice. See next.

Typical adjusted values for Rho ρ
You may find the following values of ρ to be useful in calculating resistance of tracks and connections.

For copper:

- = 1.65E-8 ohm metres approximately in MKS units where cross sections (for example W, W1, T see later) and L are all measured in metres
- = 6.50E-1 ohm metres approximately in American units where cross sections are measured in mils (thousandths of an inch) and L is in inches
- = 1.65E1 ohm metres approximately in metric units where cross sections are measured in microns (micrometres) and L is in millimetres.

For gold:

- = 2.35E-8 ohm metres approximately in MKS units where cross sections and L are all measured in metres
- = 9.35E-1 ohm metres approximately in American units where cross sections are measured in mils (thousandths of an inch) and L is in inches
- = 2.35E1 ohm metres approximately in metric units where cross sections are measured in microns (micrometres) and L is in millimetres

Cross Section Area (A)

The typical cross sectional profile of an etched track is trapezoidal, illustrated by the figure. The cross sectional area, A, of a trapezoid is found from the equation

$$A = 0.5*(W + W1)*T$$

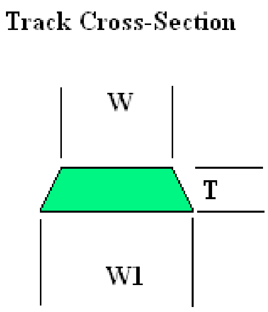

Figure 1

However, the formula R = ρL/A holds whatever the cross sectional shape. You simply have to calculate A for that shape.

Making the calculation easy

Obviously there are many convenient ways including storing a routine in a programmable calculator, or use of a spreadsheet like Microsoft Excel to build your own spreadsheet calculator. You may modify the Polar Si6000 impedance calculator spreadsheets to automatically calculate resistance, and examples of those, together with a simple Excel resistance calculator spreadsheet, can be downloaded from the Polar website. You may of course add resistance calculations into impedance spreadsheets that you make for yourself.

Need more help? Got a request or a suggestion?

We welcome your questions, comments and suggestions. Please do contact Ken Taylor at ken.taylor@polarinstruments.com

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