

Skin Depth and AC impedance of copper track

This sheet is derived from equations given in the VLSI Handbook, CRC Press, section 7.4. The skin depth becomes more important with the small dimensions of an IC process. Most RF current flows within 2 skin depths.

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First calculate the skin depth at different frequencies.

$$\text{Conductivity} := \frac{1}{1.673 \cdot 10^{-6} \cdot \text{ohm} \cdot \text{cm}}$$

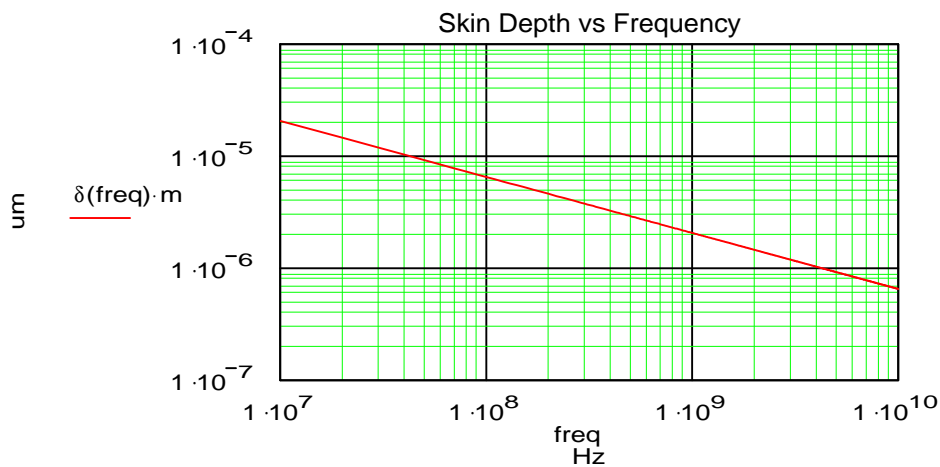
Copper = 1.673
Aluminium = 2.655

$$\mu\text{m} := 10^{-6} \text{m}$$

$$\mu_0 := (4\pi) \cdot 10^{-7} \frac{\text{henry}}{\text{m}}$$

$$\delta(\text{freq}) := \frac{1}{\sqrt{\pi \cdot \text{freq} \cdot \mu_0 \cdot \text{Conductivity}}}$$

$$\delta(1 \cdot \text{GHz}) = 2.059 \mu\text{m}$$

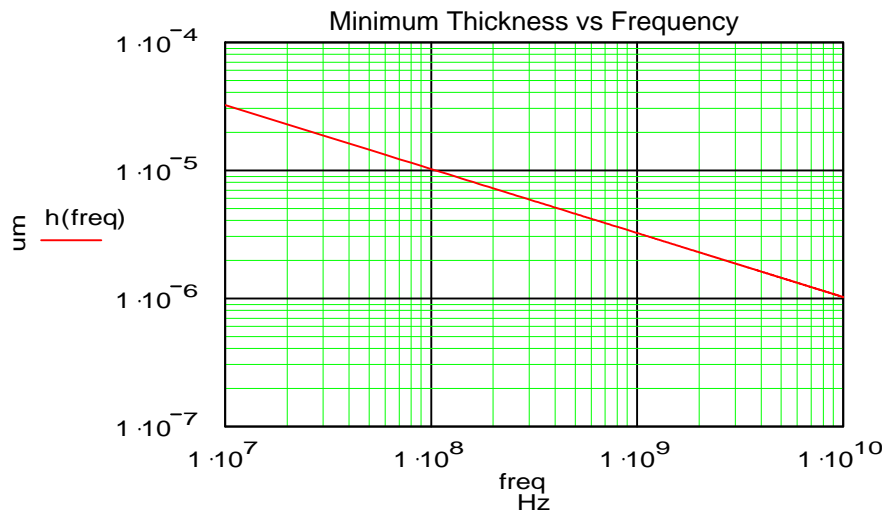


Minimum track thickness (h) at different frequencies.

$$h(\text{freq}) := \frac{\pi \cdot \delta(\text{freq})}{2}$$

$$h(1 \cdot \text{GHz}) = 3.234 \mu\text{m}$$

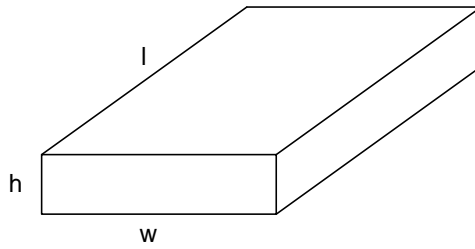
$$h(1 \cdot \text{MHz}) = 102.256 \mu\text{m}$$



This graph shows the minimum track thickness at different frequencies that should be aimed for in the design.

For a track properties as follows The DC & AC resistance is as follows

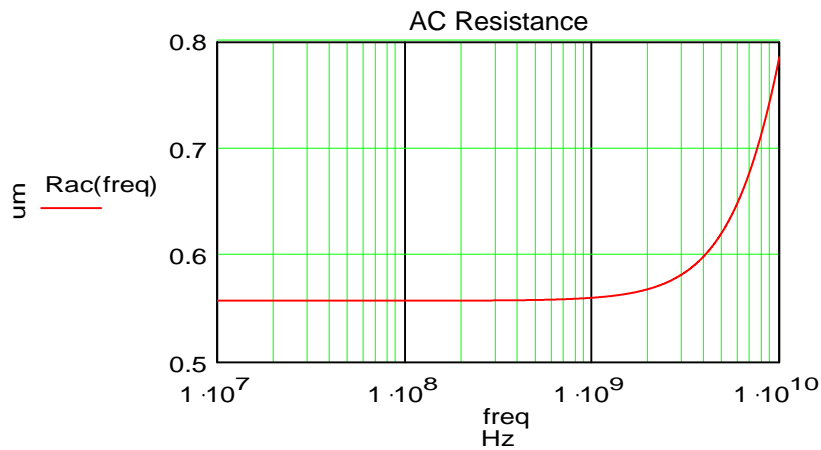
$l := 100\mu\text{m}$ $h := 1\mu\text{m}$
 $w := 6\mu\text{m}$



$$R_{dc} := \frac{l}{\text{Conductivity} \cdot h \cdot w}$$

$R_{dc} = 0.279 \text{ ohm}$

$$R_{ac}(\text{freq}) := R_{dc} \cdot \frac{h}{\delta(\text{freq})} \left(\frac{\sinh\left(\frac{h}{\delta(\text{freq})}\right) + \sin\left(\frac{h}{\delta(\text{freq})}\right)}{\cosh\left(\frac{h}{\delta(\text{freq})}\right) - \cos\left(\frac{h}{\delta(\text{freq})}\right)} + \frac{\sinh\left(\frac{h}{\delta(\text{freq})}\right) - \sin\left(\frac{h}{\delta(\text{freq})}\right)}{\cosh\left(\frac{h}{\delta(\text{freq})}\right) + \cos\left(\frac{h}{\delta(\text{freq})}\right)} \right)$$



This graph shows how the resistance of a line of given dimensions changes with frequency.