Resistive Wall Impedance with Inductive By-pass

Thick vs. Thin Wall Approximation

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4 possible formulas ...

$$Z_{m=1}^{\perp,\,\text{thick}}(\omega) = (1 + j\ \operatorname{sgn}\omega)\ \frac{cL}{\pi b^3}\sqrt{\frac{\mu_o \mu_r}{2\,\sigma_c}} \cdot \frac{\sqrt{|\omega|}}{\omega}$$

$$= (\operatorname{sgn}\omega + j)\ \frac{\mu_r\, Z_0\, L\, \delta_0}{2\,\pi\, b^3} \cdot \sqrt{\frac{\omega_0}{|\omega|}}$$

$$Z_{m=1,\,\text{ibp}}^{\perp,\,\text{thick}}(\omega) = (1 + j\ \operatorname{sgn}\omega)\ \frac{c\,\mu_0\, L}{2\,\pi\, b^2}\ \frac{1}{-j + \operatorname{sgn}\omega\left(1 + b\sqrt{\frac{\sigma_c\,\mu_0}{2\,\mu_r}}\ \sqrt{|\omega|}\right)}$$

$$Z_{m=1}^{\perp,\,\text{thin}}(\omega) = \frac{c\,L}{\pi\, b^3\, \sigma_c\, t_w \cdot \omega}$$

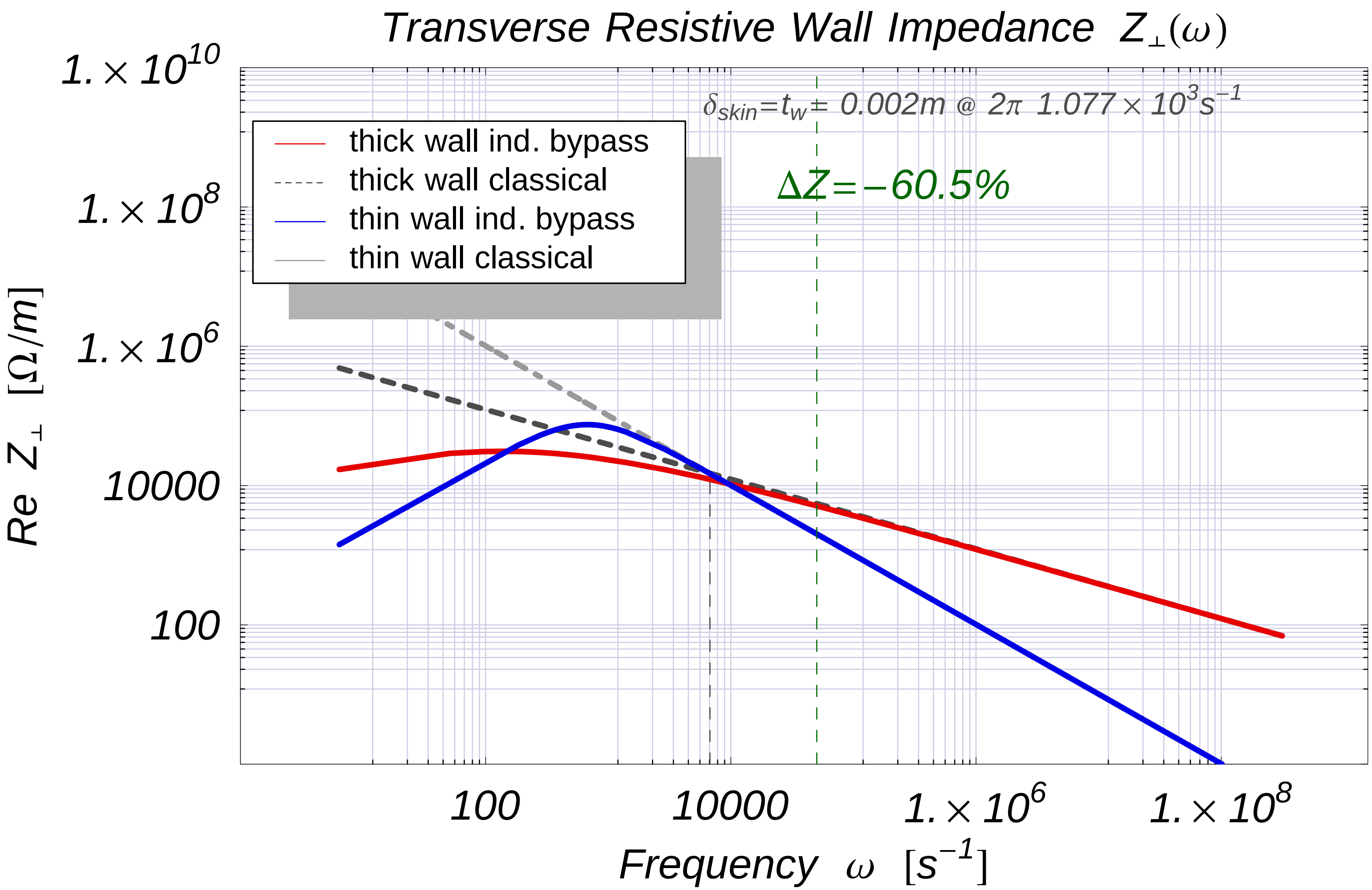
$$Z_{m=1,\,\text{ibp}}^{\perp,\,\text{thin}}(\omega) = \frac{c\,\mu_0\, L}{2\,\pi\, b^2} \cdot \frac{1}{\frac{1}{2}\, b\, t_w\, \sigma\, \mu_0 \cdot \omega - j}$$

$$= \frac{Z_0\, L}{2\,\pi\, b^2} \cdot \frac{1}{\frac{b\, t_w}{\delta_0^2\, \mu_r}\ \frac{\omega}{\omega_0} - j}$$

Standard Picture (1/2)

Copper coated stainless steel vacuum chamber

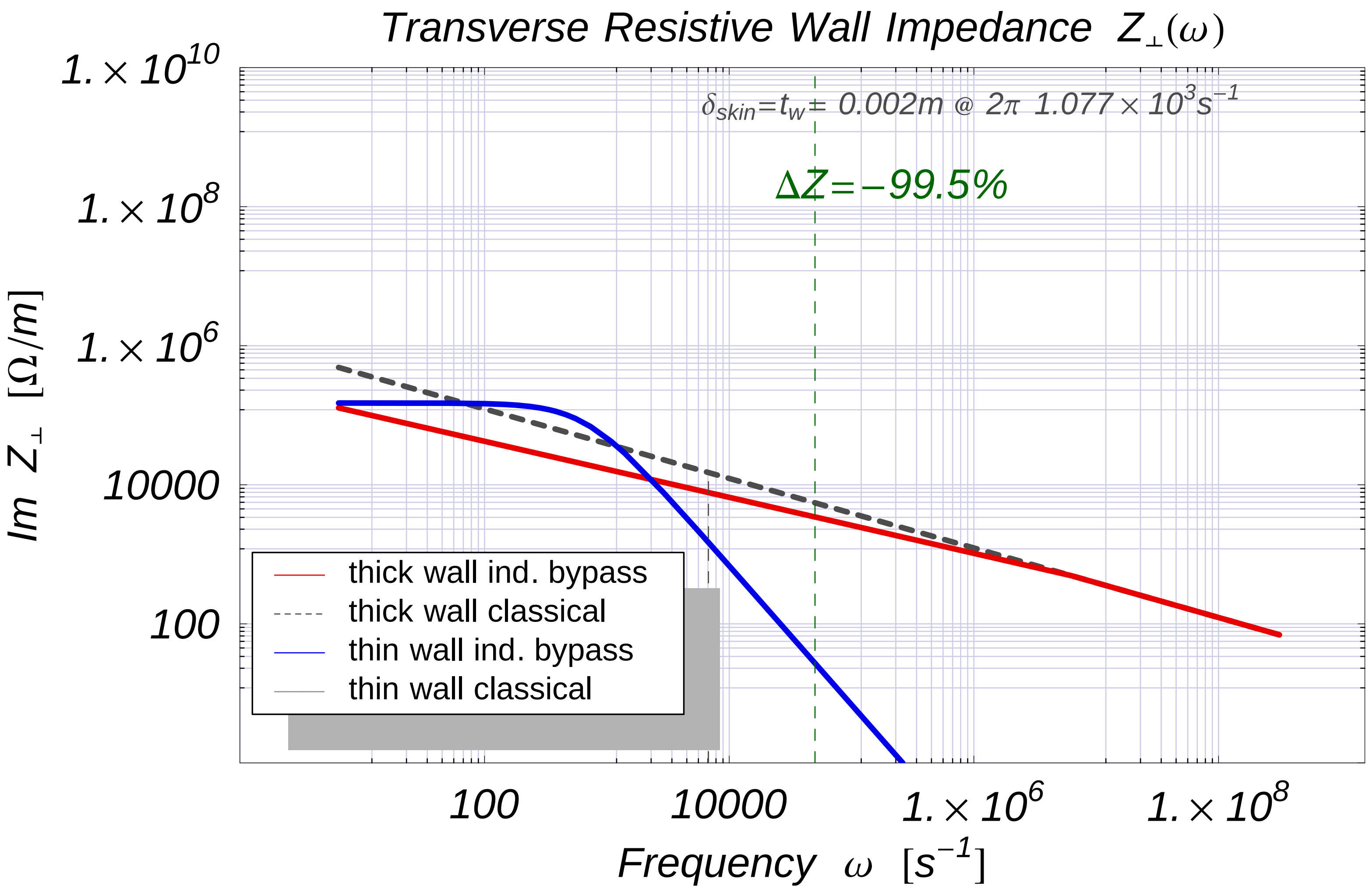
$$\rho_c = 1.7 \cdot 10^{-8}\Omega m, b = 2 \cdot 10^{-2} m, t_w = 2 \cdot 10^{-3} m$$



Standard Picture (2/2)

Copper coated stainless steel vacuum chamber

$\rho_c = 1.7 \cdot 10^{-8} \Omega m, b = 2 \cdot 10^{-2} m, t_w = 2 \cdot 10^{-3} m$

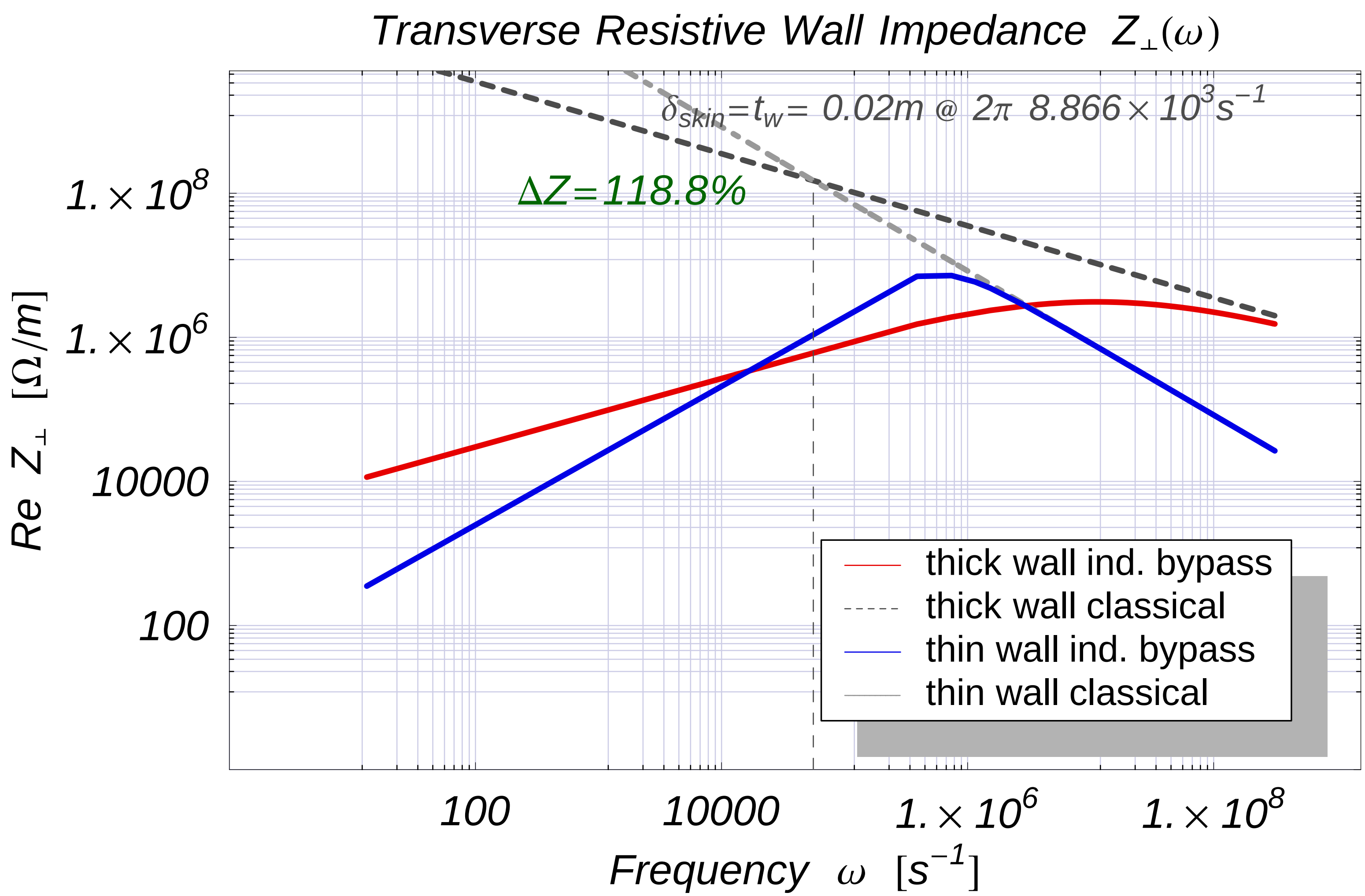


The parameters

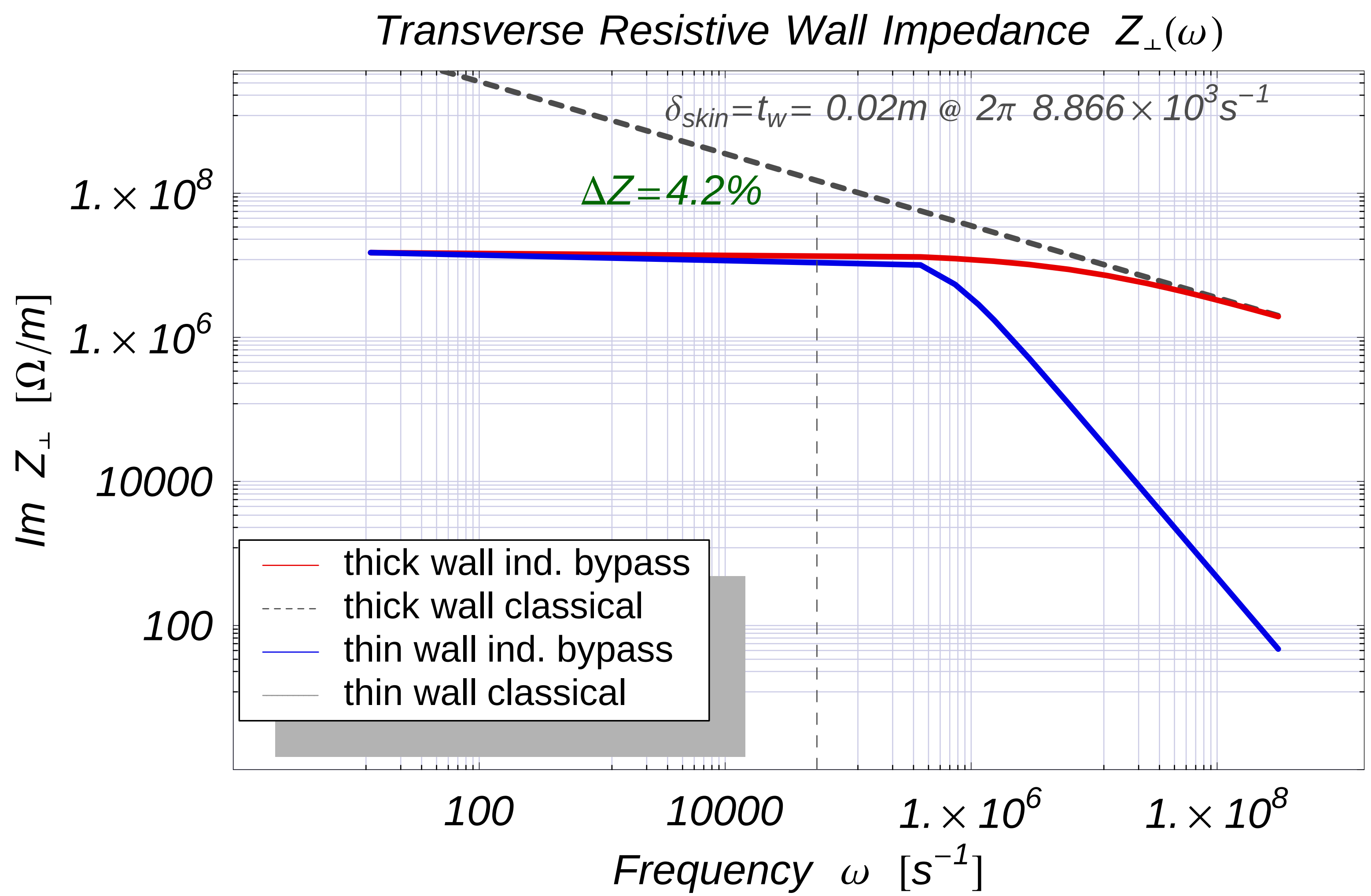
Symbol	Value	Quantity
ρ_c	$14 \cdot 10^{-6}\ (\Omega m)$	resistivity
σ_c	$7.2 \cdot 10^{4}\ (\Omega m)^{-1}$	conductivity
b	$2 \cdot 10^{-3}\ m$	tube radius (collimator distance)
t_w	$2.5 \cdot 10^{-2}\ m$	wall (collimator) thickness
μ_0	$4\pi\, 10^{-7}\ Vs(Am)^{-1}$	permeability of free space
μ_r	1	relative permeability $\mu_r = \mu/\mu_0$
ω_{lowest}	$2\pi \cdot 810^{3}\ Hz$	Lowest mode frequency line

Table 1: Standard parameters used for computing instabilities caused by the LHC graphite collimator

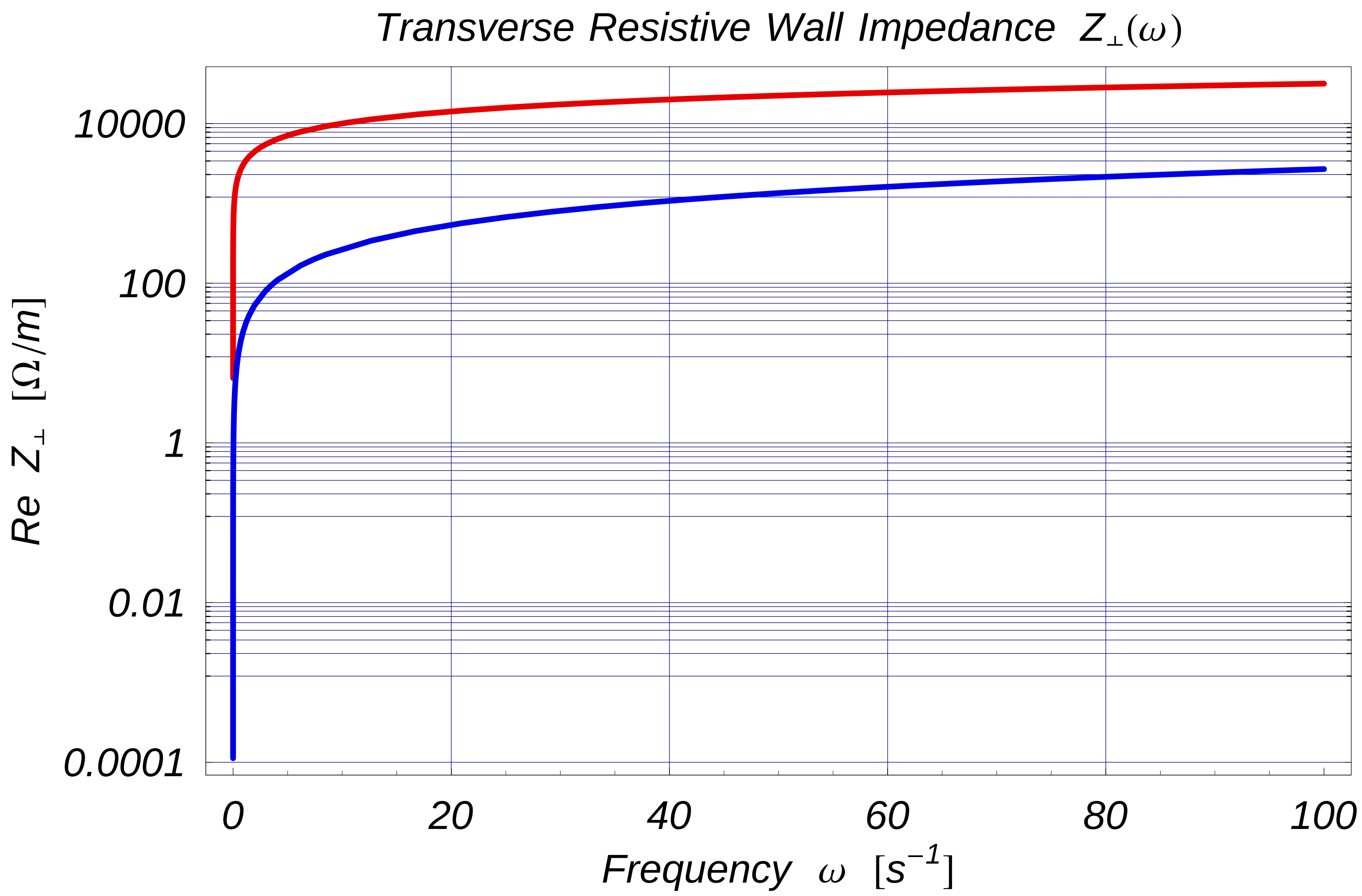
How much is the error? (1/2)



How much is the error? (2/2)



The limit $\omega \to 0$ (1/2)



The limit $\omega \to 0$ (2/2)