Current Transformer Design

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Goal: Design an easily manufacturable current transformer to handle primary currents between 0 and 20 amperes RMS. Material should be cold rolled steel due to accessibility for prototyping. Significant losses are permissible. Transformer should be linear in the provided primary current range.

Selected design is of the "doughnut" toride shape, with two hemi-torides with a gap to prevent material flux saturation.

For cold-rolled steel, the following parameters are used [CITE]:

180 = Relative Permeability (μ_r)
$2.1T$ = Saturation Flux Density (β_{max})

The following parameters are arbitrarily selected based on the known diameter of insulated 2 AWG wire, the largest reasonable for these sizes of loads:

$15mm = D_i$ = Inner Diameter
$25mm = D_o$ = Outer Diameter
$10mm = Z$ = Material Thickness

We can then calculate

$$l = \pi \cdot 0.5(D_i + D_o) = 62.83mm$$
$$A = 0.5(D_i - D_o) * Z = 0.00005m^2$$
$$MMF = N * I = 20AT$$
$$\mathbb{R} \geq \frac{MMF}{\beta_{max} \cdot A} = 190476.19AT/Wb$$

where:

l = Flux path mean length
A = Cross-sectional area
MMF = Magneto-motive flux