Calculating μ_r

The Relative Permeability of a Ferrite Toroid Core

Robert Weaver, 2013-04-15[1]

Step 1: Determine the A_L value with a test winding. Wind several turns of wire on the core, or use an existing winding that it may already have.
Measure the inductance ***L*** in ***nanoHenries***, and count the turns ***N***.
The A_L value is given by:

$$A_L = \frac{L}{N^2}$$

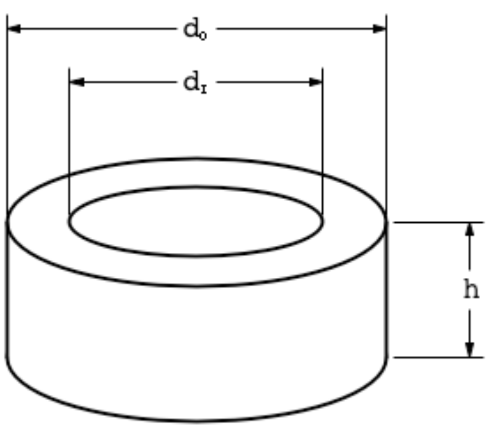
If you're only interested in finding out how to wind a coil of a given inductance, then this is all the information you need. The above formula can be rearranged to give the required number of turns for a specific inductance:

$$N = \sqrt{\frac{L}{A_L}}$$

Or, it can be rearranged to give inductance for a given number of turns:

$$L = A_L N^2$$

(Remember that units are nH. To convert to μH, divide by 1000.)



Now, to help identify the actual core material, which determines the range of frequencies over which it is useful, then the permeability must be determined using the method given in the remaining steps.

Step 2: Referring to the diagram, measure the core dimensions in ***millimeters***: Inside diameter d_I, Outside diameter d_O, and Height ***h***.

Step 3: Calculate the core cross sectional area A_C and the magnetic path length X_C:

$$A_C = \frac{(d_O - d_I)h}{2}$$

Note that if the edges of the toroid are extremely rounded, the cross sectional area will be smaller than what this calculation gives. If the radius of the rounded edges is ***r***, then the reduction in area will be πr^2. Hence:

$$A_C = \frac{(d_O - d_I)h}{2} - \pi r^2$$

The magnetic path length is given by:

$$X_C = \frac{(d_O + d_I)\pi}{2}$$

Step 4: Calculate μ_r:

$$\mu_r = \frac{A_L X_C}{0.4\pi A_C}$$

The formula can also be written as:

$$\mu_r = A_L \frac{d_O + d_I}{0.4h(d_O - d_I) - 0.8\pi r^2}$$

The value often listed by ferrite manufacturers and suppliers is *initial permeability* μ_i, which for most practical purposes is the same as the value calculated here.

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The latest version of this document can be downloaded from: http://electronbunker.ca/DLpublic/ToroidPermeability.pdf