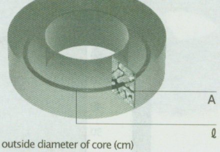
Mean Magnetic Path Length

For toroidal powder cores, the effective area (A) is the same as the cross sectional area. By definition and Ampere's Law, the effective magnetic path length is the ratio of ampere-turns (NI) to the average magnetizing force. Using Ampere's law and averaging the magnetizing force gives the formula for effective path length.



$$\ell = \frac{\pi(OD - ID)}{\ln\left(\frac{OD}{ID}\right)}$$

OD = outside diameter of core (cm)
ID = inside diameter of core (cm)
A = core cross section (effective area)
ℓ = mean magnetic path length (cm)

Q Factor

The Q factor is defined as the ratio of reactance to the effective resistance for an inductor and thus indicates its quality. The Q of wound core can be calculated using the following formula, when neglecting the effects of self-resonance caused by the distributed capacitance resulting from the differential voltage between adjacent turns.

$$Q = \frac{\omega L}{R_{dc} + R_{ac} + R_{d}}$$

Q = quality factor
ω = 2π frequency (hertz)
L = inductance (henries)
R_{dc} = DC winding resistance (ohms)
R_{ac} = resistance due to core loss (ohms)
R_{d} = resistance due to winding dielectric loss (ohms)

Core Loss

Powder cores have low hysteresis loss, minimizing signal distortion, and low residual loss. The total core loss at low flux densities is the sum of three frequency dependent losses of hysteresis loss, residual loss, and eddy current loss. The core loss is calculated from the following Legg's equation.

$$\frac{R_{ac}}{\mu L} = aB_{max}f + cf + ef^2$$

- ef^2: Eddy current loss
- cf: Residual loss
- $aB_{max}f$: Hysteresis loss
- $\frac{R_{ac}}{\mu L}$: Total loss factor

Where R_{ac} = core loss resistance (ohms)
a = hysteresis loss coefficient
c = residual loss coefficient
e = eddy current loss coefficient
μ, L, B_{max}, f = same as mentioned before

When a varying magnetic field passes through the core, eddy currents are induced in it. Joule heat loss by this currents is called eddy current loss. Hysteresis loss is due to the irreversible behavior in hysteresis curve and equal to the enclosed area of the loop. The other core loss is called residual loss.