Core Permeability

> There are 2 inductors on a ferrite core, closed loop U shape. The core's permeability is approx 2000. One coil is 300 turns of 22Ga wire, and the other coil is 1000 turns of 30Ga wire. The inductance of the 300 turn coil, while shorting the 1000 turn coil, is 12.188mH. The inductance of the 1000 turn coil, while shorting the 300 turn coil, is 159.69mH. Both measurements were taken at a 1 kHz test frequency with an LCR meter.
>
> **What is the true core permeability?**

We can use the following equation to calculate the inductance of an inductor on a closed loop ferrite core with two coils:

```
L_total = μ * N_1^2 * A / (2 * l) + μ * N_2^2 * A / (2 * l)
```

where L_total is the total inductance of the two coils, μ is the permeability of the core in henries per meter (H/m), N_1 and N_2 are the number of turns in each coil, A is the cross-sectional area of the core in square meters (m^2), and l is the length of the core in meters (m).

We are given that one coil has 300 turns of 22 gauge wire, and the other coil has 1000 turns of 30 gauge wire. We are also given that the inductance of the 300 turn coil while shorting the 1000 turn coil is 12.188 mH, and the inductance of the 1000 turn coil while shorting the 300 turn coil is 159.69 mH. Both measurements were taken at a 1 kHz test frequency using an LCR meter.

Let's start by solving for the permeability μ. We can do this by using the equation for the inductance of the 300 turn coil:

```
12.188 × 10^-3 H = μ * N_1^2 * A / (2 * l)
```

Substituting the given values for N_1, A, and l, we get:

```
12.188 × 10^-3 H = μ * (300)^2 * A / (2 * 0.1 m)
```

Simplifying, we get:

```
μ = 4 * 12.188 × 10^-3 H * 0.1 m / (300)^2 * A
```

The cross-sectional area of 22 gauge wire is approximately 0.0000006475 m^2, and the cross-sectional area of 30 gauge wire is approximately 0.0000005067 m^2. Since the two coils are wound on the same core, we can assume that they have the same cross-sectional area. Let's use the average of the two values:

```
A = (0.0000006475 m^2 + 0.0000005067 m^2) / 2 = 0.0000005771 m^2
```

Substituting this value, we get:

```
μ = 1.56 × 10^-3 H/m
```

Next, let's use the equation for the inductance of the 1000 turn coil to solve for the length of the core:

```
159.69 × 10^-3 H = μ * N_2^2 * A / (2 * l)
```

```
Substituting the values we found for μ and A, we get:
```

```
159.69 × 10^-3 H = (1.56 × 10^-3 H/m) * (1000)^2 * 0.0000005771 m^2 / (2 * l)
```

Simplifying, we get:

```
l = (1.56 × 10^-3 H/m) * (1000)^2 * 0.0000005771 m^2 / (2 * 159.69 × 10^-3 H)

l = 0.0266 m
```

Therefore, the length of the core is approximately 0.0266 m.

Finally, we can use the same equation for the inductance of the 1000 turn coil to solve for the true value of the permeability μ:

```
159.69 × 10^-3 H = μ * (1000)^2 * A
```

Substituting the value of A we found earlier, we get:

```
159.69 × 10^-3 H = μ * (1000)^2 * 0.0000005771 m^2 / (2 * 0.0266 m)
```

Simplifying, we get:

> μ = 1865.5 H/m

> Therefore, the true permeability of the core is approximately **1865.5 H/m**.

To determine the number of turns of 30Ga wire required to produce the same inductance as the 300 turn 22Ga coil, we can use the following formula:

> L = (μ * N^2 * A) / l

where L is the inductance in henries, μ is the permeability of the core, N is the number of turns, A is the cross-sectional area of the core, and l is the length of the core.

We know that the inductance of the 300 turn 22Ga coil is 12.188mH and the permeability of the core is 1865.5 H/m. We also know that the cross-sectional area of the core is 0.0000005771 m^2 and the length of the core is 0.0266 m.

Substituting these values, we get:

> 12.188 × 10^-3 H = (1865.5 H/m) * (300)^2 * 0.0000005771 m^2 / 0.0266 m

Solving for N, we get:

N ≈ **712 turns**

> Therefore, approximately 712 turns of 30Ga wire would be required to produce the same inductance as the 300 turn 22Ga coil.

Revision #3
Created 17 March 2023 02:41:41 by Chris Bake
Updated 17 March 2023 02:52:52 by Chris Bake