EMPossible

Electromagnetics:
Electromagnetic Field Theory

Example 2 – MacDonald's Straw Inductor

1

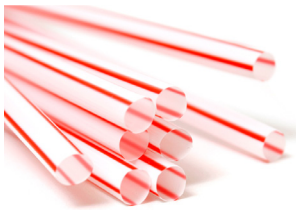
What is a McDonald's Straw Inductor?

It is possible to make an inductor with a reasonably accurate inductance, by wrapping magnet wire around a MacDonald's straw.

How can this be done? What is the design rule?

Solution

First, you need some magnet wire and a straw from MacDonald's. Magnet wire has a very thin insulating jacking so more windings can be fit.



The radius a of a MacDonald's straw is

$$a = 3.7 \text{ mm}$$

Let's say we have 22 AWG for this example. The diameter d of the coated wire is

$$d = 0.644 \text{ mm}$$

2

Derivation of Design Rule

The inductance per unit length is

$$\frac{L}{\ell} = \mu S \left(\frac{N}{\ell}\right)^2$$

For this problem with an air core,

$$\mu = \mu_0 \mu_r = \mu_0 (1.0) = \mu_0$$

$$S = \pi a^2$$

The inductance per unit length becomes

$$\frac{L}{\ell} = \mu_0 \cdot \pi a^2 \cdot \left(\frac{N}{\ell}\right)^2 = \mu_0 \pi \left(a \frac{N}{\ell}\right)^2$$

3

Derivation of Design Rule

If the inductor is wrapped tightly with only one layer of windings, the turn density is

$$\frac{N}{\ell} = \frac{1}{d}$$

The inductance per unit length becomes

$$\frac{L}{\ell} = \mu_0 \pi \left(a \frac{N}{\ell}\right)^2 = \mu_0 \pi \left(\frac{a}{d}\right)^2 = \left(1.2566 \times 10^{-6} \text{ H/m}\right) \pi \left(\frac{3.7 \text{ mm}}{0.644 \text{ mm}}\right)^2$$

The design rule is

$$\frac{L}{\ell} \approx 1.3 \times 10^{-4} \text{ H/m} \quad \rightarrow \quad \boxed{\ell \text{ (mm)} \approx \frac{L \text{ (nH)}}{130}}$$

You can use this to easily make your own inductors!

4