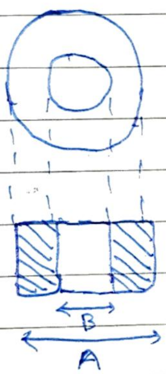
Project Notes

Toroid Calculations.

- OUR TOROID CORE 1 :- (From lab)

Manufacturer :- Cosmo Ferrites Limited.
Part NO. :- T 4016

- Dimensions



A = 39.9 ± 0.6 mm

B = 24.1 ± 0.5 mm

C = 16.0 ± 0.3 mm

- Effective Parameters

Effective Path Length = l_e = 96.4 mm = 0.0964 m

Eff. Cross sectional Area = A_e = 123.8 mm^2 = 1.238×10^{-4} m^2

- Formulas :

① L = Inductance of toroid core of rectangular cross section

$$\boxed{L = \frac{\mu N^2 c \ln(a/b)}{2\pi}} \quad , \mu = \mu_0 \mu_r$$

N = total turns ; a, b & c are given above.

(2) Required max value of Sine Voltage

$$\boxed{V_{rat} \geq N_p \cdot A_\phi \cdot B_{max} \cdot \omega_{max}}$$

N_p = No. of primary turns.
$A_\phi = A_e$ = cross sation area of toroid.
B_{max} = peak flux density
W_{max} = Max frequency.

- $B_{max} = 0.3\ T$

  & frequency Range = 50 Hz to 10 KHz

As given in problem statement.

(3) Required peak current :

$$\boxed{I_{rat} \geq H_{max} \frac{l_\phi}{N_p}}$$

l_ϕ ~~= l_e~~ = perimeter of core.

Note :-

- Hence, to generate a certain flux density,

if $N_p \uparrow$ then $I_{rat} \downarrow$ but $V_{rat} \uparrow$ and vice versa, so we need to chose N_p wisely, based on available power supply, component ratings, toroid core and frequency.

- Calculation:

Given → $B_{max} = 0.3\ T$
frequency = 50 Hz to ~~#~~ 10 KHz

Let $N_p = N_s = N$

Toroid core → $a = 39.9\ mm = 0.0399\ m$
$b = 24.1\ mm = 0.0241\ m$
$c = 16.0\ mm = 0.016\ m$
$l_e = 0.0964\ m$
$A_e = 1.238 \times 10^{-4}\ m^2$

μ_r is not given, hence assuming the value of $\underline{\mu_r = 2000}$

$\therefore\ \mu = \mu_0 \mu_r = 4\pi \times 10^{-7} \times 2000$

1) $L = \dfrac{\mu N^2 c \cancel{\ln(a/b)} \ln(a/b)}{2\pi}$

$= \dfrac{4\pi \times 10^{-7} \times 2000 \times 16 \times 10^{-3} \ln\left(\frac{39.9}{24.1}\right)}{2\pi} \times N^2$

$= 4 \times 16 \times 10^{-7} \times 0.5041 \times N^2$

$\boxed{L = 3.22665 \times N^2\ \mu H}$ ——— (1)

Note :- When we tested our toroid core with $N = 30$, we got $L = 15\ mH$ approx. We tested it with a standard LCR meter. Hence, the μ_r turns out to be around 10000.
$\therefore$ Actual $\mu_r = 10000$ for toroid core

Hence, considering $\underbrace{\mu_r = \cancel{10}\ 9000 \pm 30\%}$

This one is the closest one to the measured μ_r. It is given on the manufacturer's website.

$\therefore \boxed{L = 16.13325 \times N^2 \ \mu H}$ —— (2)

2) $V_{sat} \geq N \cdot A_\phi \cdot B_{max} \cdot \omega_{max}$

$\therefore V_{sat} \geq N \times 1.238 \times 10^{-4} \times 0.3 \times f_{max} \times 2\pi$

$\boxed{V_{sat} \geq 2.33357 \times 10^{-4} \times N \times f_{max}}$ —— (3)

3) $B = \mu_0 H$

$\therefore H_{max} = B_{max}/\mu_0 = 0.3\,T/4\pi \times 10^{-4}$

$\therefore \boxed{H_{max} = 238.7 \ A/m}$

Hence $I_{sat} \geq H_{max} \times \dfrac{l_\phi}{N}$

$\cancel{I_{sat} \geq 238.7 \times \dfrac{\cancel{0.0964}\ 2\pi \times a/2}{N}}$

$\cancel{\geq 238.7 \times \dfrac{\pi \times 0.0399}{N}}$

$l_\phi = 2\pi\, r_{eff}$

$r_{eff} = 24.1 + 16.0 = 40.1 \ mm = 0.0401 \ m$

$l_\phi = 2\pi \times 40.1 \ mm = 251.95 \ mm$

$$\therefore \quad I_{sat} \geq 238.7 \times \frac{251.95\,mm}{N}$$

$$\boxed{I_{sat} \geq \frac{60.14}{N}} \quad \text{——} \; 4$$

4) Impedance

Measured DCR of the toroid with 30 turns on the LCR meter, $R = 7.8\,\Omega$ to $13.2\,\Omega$

$\therefore$ Let DCR be $R \cong 10\,\Omega$ (For $N = 30$)

$$\boxed{Z = 2\pi f L} \quad \text{——} \; 5$$

Hence, using equations 2, 3, 4 & 5, we can determine the value of N, based on V_{sat} & I_{sat}.