HW #3

EE745

A. Keyhani

Problem 1. An iron-core transformer which has two windings is shown in Fig. 1. $N_1 = 50$ turns, $N_2 = 100$ turns, and $\mu_r = 4000$ Calculate L_{12}, L_{m1} and L_{m2}. and polarity (P.3) of coupled coils with appropriate dots.

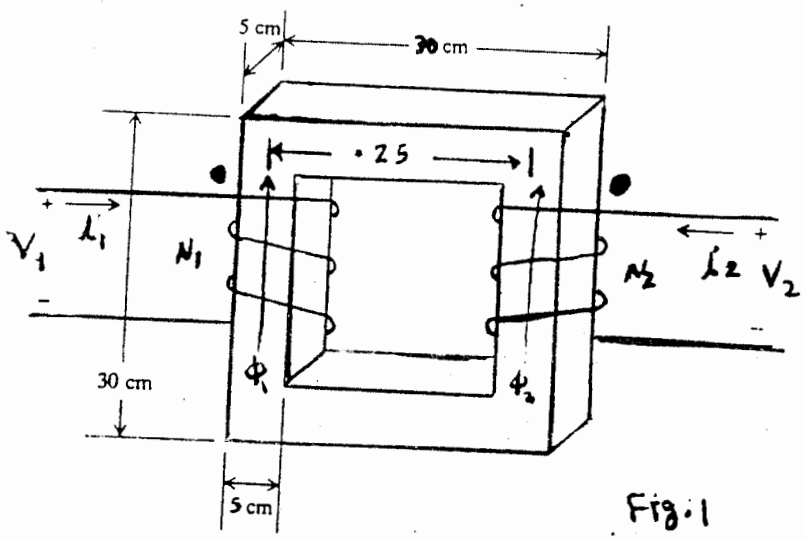


Fig. 1

Solution

$$\mathcal{R}_m = \frac{l}{\mu_i A} \qquad H^{-1} \quad \mu_i = \mu_0 \mu_{ri} = (4000)(4\pi \times 10^{-7})$$

$$A = (.05)(.05) = .0025 \quad m^2$$

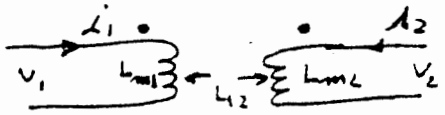
$$l = 4(0.30 - .05) = 4(.25) = 1 \ m$$

$$\mathcal{R}_m = 79,577 \ H^{-1}$$

$$L_{12} = \frac{N_1 N_2}{\mathcal{R}_m} = \frac{(50)(100)}{79,577} = 0.0628 \ H$$

$$L_{m1} = \frac{N_1^2}{\mathcal{R}_m} = \frac{50^2}{79,577} = .0314 \ H \qquad L_{m2} = \frac{N_2^2}{\mathcal{R}_m} = \frac{100^2}{79,577} = .1257 \ H$$

Equivalent circuit model:



Solution
Problem set #

A. Keyhani (5)

EE743

Problem 1. Express the force of attraction between the iron faces of the air gap in Fig. 1. Assume N = 1000 turns, $g = 10^{-3}$ m and the switch "s" closes on the reactor when the input voltage V, is at its maximum value with the amplitude of 120 volts (f = 60 Hz). Neglect the reluctance of the iron. Assume r = 1 Ω and Le = .01 H

p.10

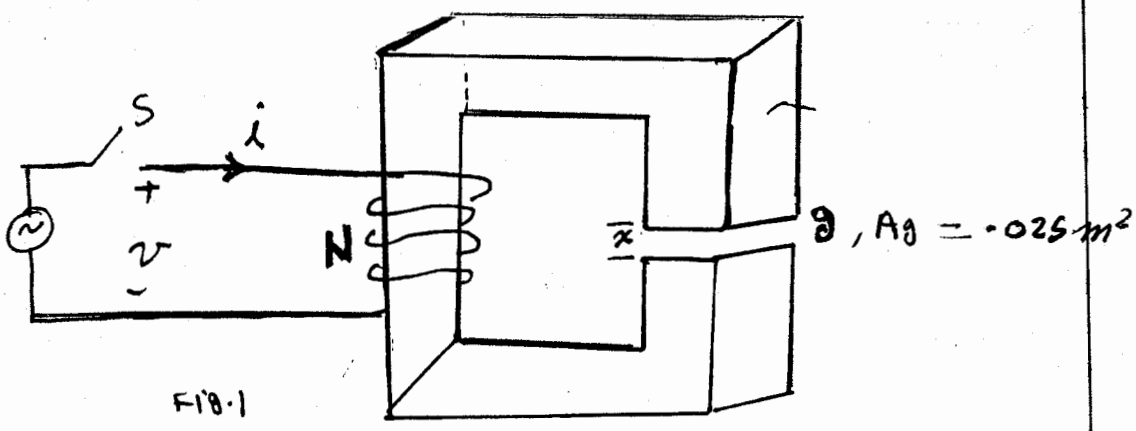


Fig. 1

solution

$$f_e = \frac{\partial W_c(i,x)}{\partial x}$$

$$W_c = W_f = \tfrac{1}{2} L(x)\, i^2 \quad , \quad L(x) = \frac{N^2}{\mathcal{R}_g}$$

$$\mathcal{R}_g = \frac{g}{\mu_0 A_g} \qquad L(x) = \frac{N^2 \mu_0 A_g}{x}$$

$$W_c = \frac{1}{2} \frac{N^2 \mu_0 A_g}{x} i^2 \quad , \quad f_e = \frac{\partial W_c}{\partial x} = -\frac{1}{2} \frac{N^2 \mu_0 A_g}{x^2} i^2$$

when $x = 1$ mm

$$V = ri + L\frac{di}{dt} \qquad i(t) = i_{ss} + i_{tr} = i_{ss} + A e^{-\frac{r}{L}t}$$

$$V = 120 \cos 377t \qquad L = 31.42$$

$$i_{tr} = A e^{-31.42t} \to 0$$

$$i(t) = i_{ss} = \frac{V}{\sqrt{r^2 + (\omega L)^2}} \sin 377t = .01 \sin 377t$$

$$f_e = 1.57 \sin^2 377t \qquad N - m$$

fe