National University of Singapore

Department of Electrical & Computer Engineering

EE1002: Introduction to Circuits and Systems

Tutorial - 7 Solution (Magnetic Circuits)

Year 2013-14

Q.1 In a toroidal core the flux is given by

$$\phi = \frac{\mu N i r^2}{2R} = \frac{\mu \times (N = 200) \times (i = 0.05\, sin(200t)) \times (r = 10^{-2})^2}{2 \times (R = 0.1)} = 0.005 \mu sin(200t) \text{ Wb}$$

The induced voltage, e is given by

$$e = N\frac{d\phi}{dt} = (N = 200) \times 0.005 \times \mu \times 200 cos(200t) = 200 \times \mu \times cos(200t)$$

However, the induced voltage is given by $0.5cos(200t)$ and equating it to the above eqn. we have,

$$0.5 \times cos(200t) = 200 \times \mu \times cos(200t) \Rightarrow \mu = 2.5 \times 10^{-3} \Rightarrow \mu_r = 1989.4$$

Thus, the flux, ϕ in the core is given by

$$\phi = 0.005 \times \mu \times sin(200t) \text{ Wb } = 0.005 \times 2.5 \times 10^{-3} \times sin(200t) \text{ Wb } = 1.25 \times 10^{-5} \times sin(200t)\, Wb$$

Q.2 The parameters given are:

$$l_g = 0.2 \text{ cm}, A_c = 20\, cm^2\, , B = 0.5\, Wb/m^2\, , i = 10 \text{ A}\, , \text{and } \Re_c \simeq 0$$

The reluctance of the air-gap is given by

$$\Re_g = \frac{l_g}{\mu_0 \times A_c} = \frac{0.2 \times 10^{-2}}{4\pi \times 10^{-7} \times 20 \times 10^{-4}} = 795.8 \times 10^3$$

The flux, ϕ in the air-gap is given by

$$\phi = B \times A_c = 0.5 \times 20 \times 10^{-4} = 1 \text{ mWb}$$

We have

$$(\text{mmf} = N \times i) = 2 \times \Re_g \times \phi \Rightarrow (N \times 10 \text{ A }) = 2 \times (795.8 \times 10^3) \times 10^{-3} \Rightarrow N {\simeq} 159$$

Q.3 The parameters given are:

$$L_1 = 1.0 \text{ H}, L_2 = 2.0 \text{ H}, M = 0.5 \text{ H}, i_1 = 1.0 \text{ A}, \text{and } i_2 = 0.5 \text{ A}$$

The flux-linkage of coil-1 is given by

$$\lambda_1 = L_1 \times i_1 - M \times i_2 = 1.0\, H \times 1.0\, A - 0.5\, H \times 0.5\, A = 0.75 \text{ Wb-turns}$$

Similarly, the flux-linkage of coil-2 is given by

$$\lambda_2 = -M \times i_1 + L_2 \times i_2 = -0.5\, H \times 1.0\, A + 2.0\, H \times 0.5\, A = 0.5 \text{ Wb-turns}$$

Q.4 The secondary coil is open-circuit and therefore we have $i_2 = 0$. When the switch is closed at $t = 0$, we have

$$v_1(t) = 12\text{ V} = L_1 \times \frac{di_1}{dt} \Rightarrow i_1(t) = 120t$$

Substituting in the voltage equation, we have

$$v_2(t) = M \times \frac{di_1}{dt} = 1.0 \times 120 = 120\text{ V}$$

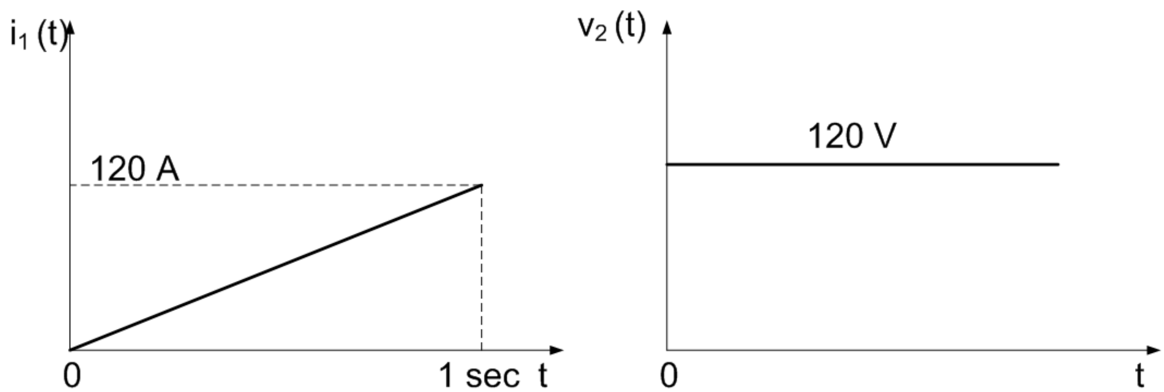

Figure 1: Q.1

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