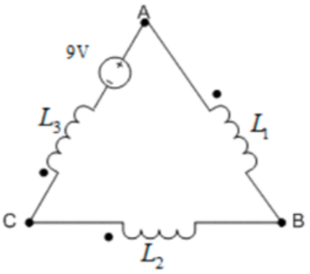
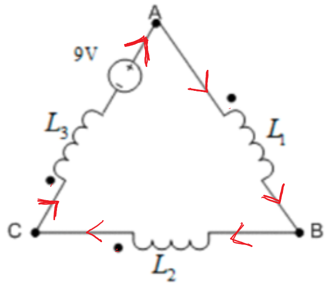
L16-BET-18Dec2021-Teams6-7

16 December 2021 17:40

Illustration 9 - Magnetic Circuits

Three magnetically coupled inductive coils having the following data are connected as shown in Figure. $L_1 = 0.1$ H; $L_2 = 0.2$ H; $L_3 = 0.4$ H; $k_{12} = 0.4$; $k_{23} = 0.5$; $k_{31} = 0.5$. Find the equivalent inductance of the circuit.





$L_{1Net} = L_1 - M_{12} + M_{13}$

$L_{2Net} = L_2 - M_{21} - M_{23}$

$L_{3Net} = L_3 + M_{31} - M_{32}$

$\left\{ \begin{array}{l} M_{13} = M_{31} \\ M_{12} = M_{21} \\ M_{32} = M_{23} \end{array} \right.$

$L_{eq} = L_{1Net} + L_{2Net} + L_{3Net}$

$K_{12} = \frac{M_{12}}{\sqrt{L_1 L_2}}$

$$L_{eq} = L_1 + L_2 + L_3 - 2M_{12} + 2M_{13} - 2M_{23}$$
$$L_{eq} = L_1 + L_2 + L_3 - 2K_{12}\sqrt{L_1L_2} + 2K_{13}\sqrt{L_1L_3} - 2K_{23}\sqrt{L_2L_3} = \mathbf{0.5041\ H}$$

$K_{23} = \frac{M_{23}}{\sqrt{L_2 L_3}}$

$K_{13} = \frac{M_{13}}{\sqrt{L_1 L_3}}$

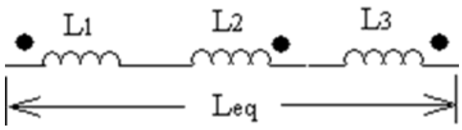
Illustration 10 - Magnetic Circuits

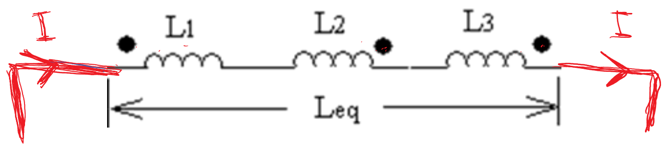
Three magnetically coupled inductive coils having the following data are connected in series as shown in Figure.

$L_1 = 0.12$ H; $L_2 = 0.14$ H; $L_3 = 0.16$ H

$k_{12} = 0.3$; $k_{23} = 0.6$; $k_{31} = 0.9$

Find the equivalent inductance of the circuit.





$$L_{1-Net} = L_1 - M_{12} - M_{13} = 0.12 - 0.03888 - 0.124707 = -0.043587\ H$$

$K_{12} = \frac{M_{12}}{\sqrt{L_1 L_2}}$

$$L_{2-Net} = L_2 - M_{21} + M_{23} = 0.14 - 0.03888 + 0.089799 = 0.190919\ H$$

$K_{13} = \frac{M_{13}}{\sqrt{L_1 L_3}}$

$$L_{3-Net} = L_3 + M_{32} - M_{31} = 0.16 + 0.089799 - 0.124707 = 0.125092$$

$$L_{total} = L_{1-Net} + L_{2-Net} + L_{3-Net} = -0.043587 + 0.190919 + 0.125092 = \mathbf{0.272424}$$

$K_{23} = \frac{M_{23}}{\sqrt{L_2 L_3}}$

OR

$$L_{eq} = L_1 + L_2 + L_3 - 2M_{12} - 2M_{13} + 2M_{23}$$

$$K = \frac{M}{\sqrt{L_1 L_2}}$$

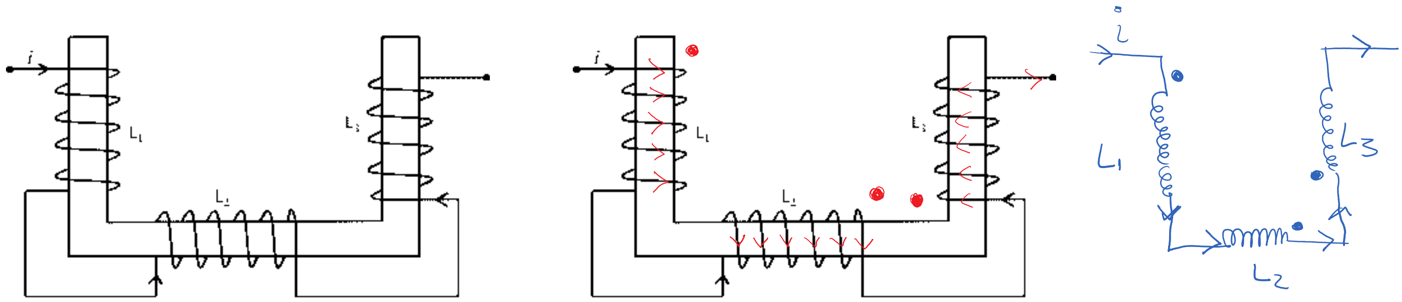
$$M_{12} = K_{12}\sqrt{L_1L_2} = 0.03888\ and\ M_{13} = K_{13}\sqrt{L_1L_3} = 0.124707\ and\ M_{23} = K_{23}\sqrt{L_2L_3} = 0.089799$$

$$L_{eq} = 0.12 + 0.14 + 0.16 - 2M_{12} - 2M_{13} + 2M_{23} = \mathbf{0.272424\ H}$$

Illustration 11 - Magnetic Circuits

Three magnetically coupled inductive coils having the following data are connected in series as shown in Figure. L_1 = 0.3 H; L_2 = 0.6 H; L_3 = 0.8H and the coefficients of coupling are ,k_{12} = 0.8; k_{23} = 0.75; k_{31} = 0.5

Draw the dotted equivalent circuit of the figure, also find the equivalent inductance of the circuit.



$$L_{eq} = L_1 + L_2 + L_3 - 2M_{12} + 2M_{13} - 2M_{23}$$

$$L_{eq} = L_1 + L_2 + L_3 - 2K_{12}\sqrt{L_1 L_2} + 2K_{13}\sqrt{L_1 L_3} - 2K_{23}\sqrt{L_2 L_3} = 0.4719\ H$$

Illustration 12 - Magnetic Circuits

K

Two similar coils have a coupling coefficient of 0.4. When they are connected in series aiding, the equivalent inductance is 560 mH. Calculate:

(i) Self-inductance of both the coils

(ii) Total inductance when the coils are connected in series opposition

(iii) Total energy stored due to a current of 3 A when the coils are connected in series opposition.

$$L_{eq} = 560 \times 10^{-3}$$
$$L_1 = L_2 = L$$
$$K = 0.4$$

(i)

$$L_{eq} = L_1 + L_2 + 2M_{12}$$

(iii)

$$E = \frac{1}{2} L_{eq} I^2 = \frac{1}{2} \times 0.24 \times (3^2) = 1.08\, Joules$$

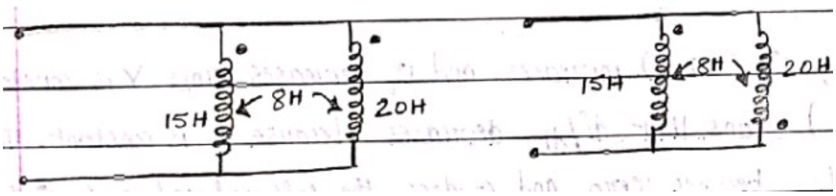
$$560 \times 10^{-3} = L + L + 2 \times (0.4 \times \sqrt{L \times L})$$
$$L = 0.2\ H$$

(ii)

$$L_{eq} = L_1 + L_2 - 2M_{12}$$
$$L_{eq} = 0.2 + 0.2 - 2 \times \left(0.4 \times \sqrt{0.2 \times 0.2}\right) = 0.24\ H$$

Illustration 13 - Magnetic Circuits

Two coils of self-inductances 15 H and 20 H are connected in parallel. If the mutual inductance between the coils is 8 H, find the total inductance of the circuit when (i) the mutual fluxes aid each other, and (ii) the mutual fluxes opposes each other.



(i) When mutual fluxes aid each other:

$$L_1 = 15 + 8 = 23$$
$$L_2 = 20 + 8 = 28$$
$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2} = 12.63\ H$$

(ii) When mutual fluxes opposes each other:

$$L_1 = 15 - 8 = 7\ H$$
$$L_2 = 20 - 8 = 12\ H$$
$$L_{eq} = \frac{L_1 L_2}{L_1 + L_2} = 4.42105\ H$$