Paper 1, TDC Part-1
Chapter– 1, Introduction to Passive Elements
Inductor Lecture 6

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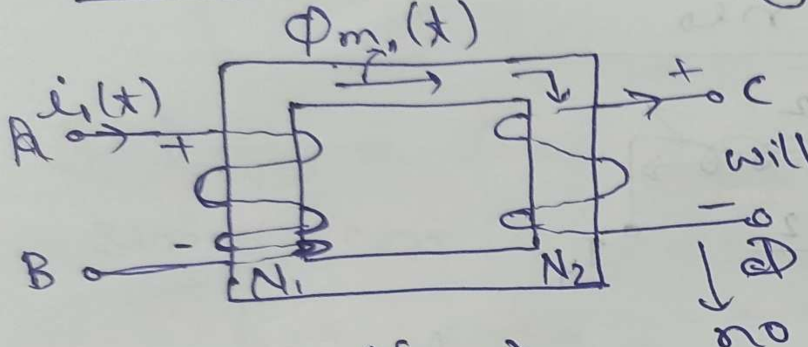
Introduction to Passive Elements- Inductor

When coils carry time varying current :→

ϕ_{m1} & i_1 in phase



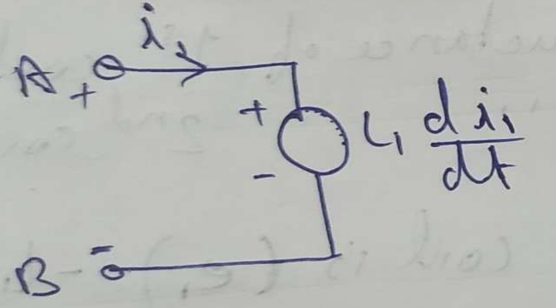
As per Faraday's law, these will voltage at terminal CD

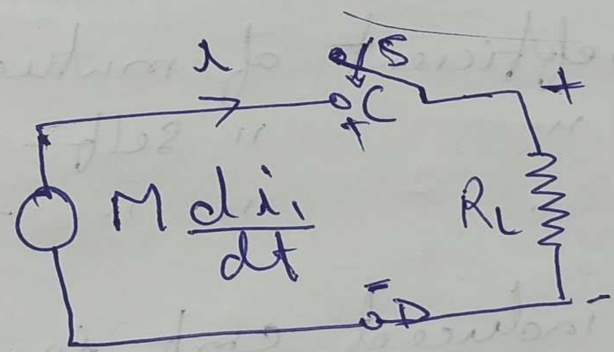
$$N_2 \frac{d(\phi_{m1} t)}{dt} = \frac{d[N_2 \phi_{m2}(t)]}{dt}$$

$$= \frac{d(M i_1)}{dt} = M \frac{di_1}{dt}$$

$$e_1 = \frac{d(L_1 i_1)}{dt}$$

$$= L_1 \frac{d i_1(t)}{dt}$$





For increasing current,

$$\frac{di_1}{dt} > 0$$

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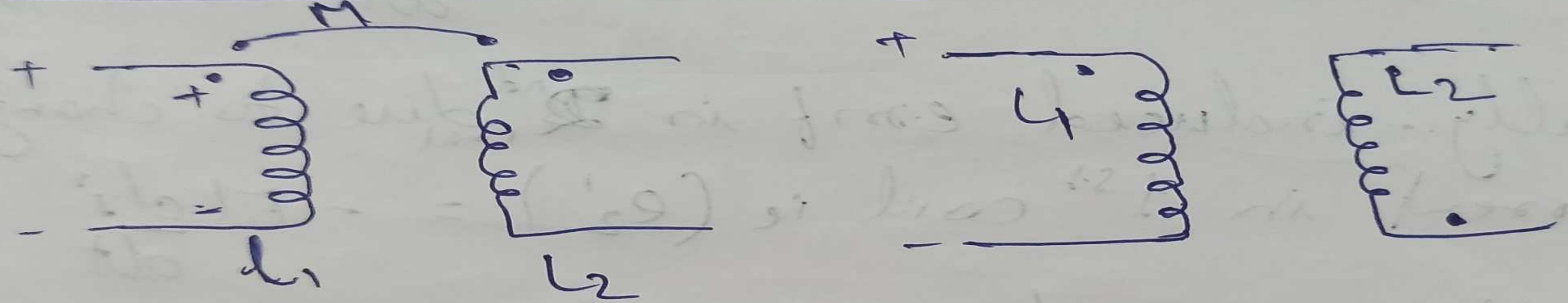
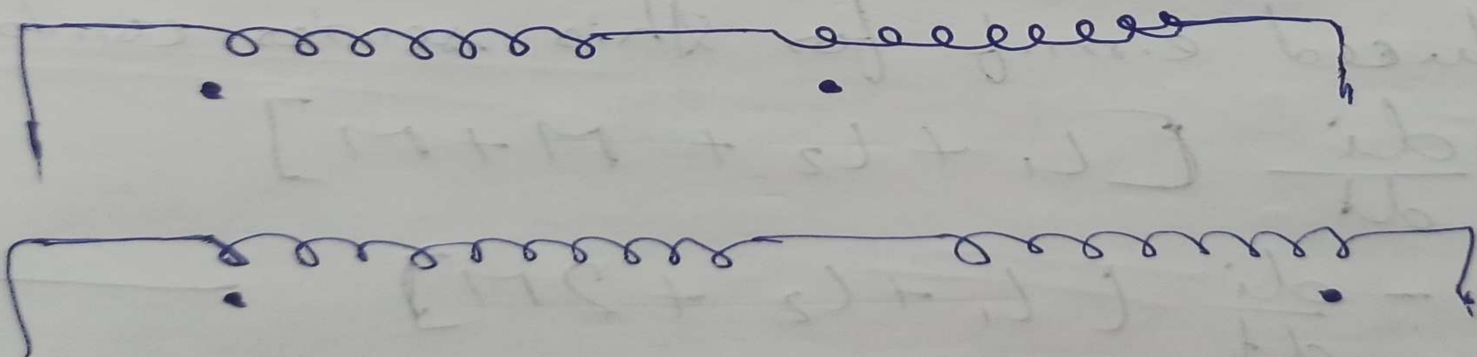
For increasing current,

$$\frac{di_1}{dt} > 0$$

and $$V_{AB} = \frac{L\,di_1}{dt}$$

Dot convention :-





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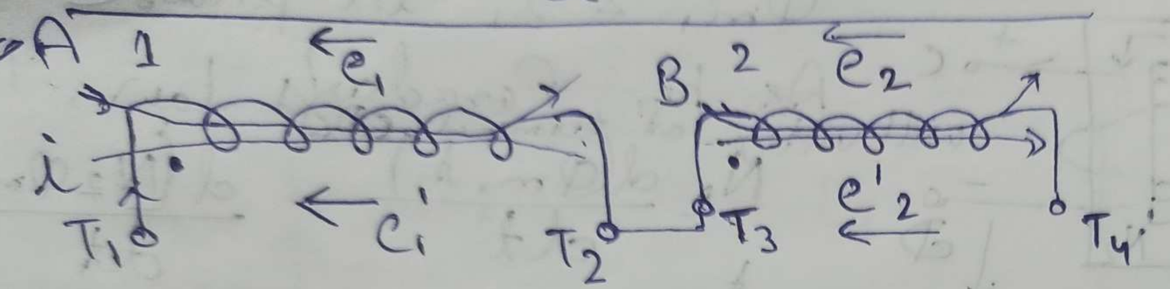
Inductance in Series

Case 1



(i) Let the two coils be so joined in series that their fluxes are additive i.e. in the same direction

Let M = coefficient of mutual inductance

L_1 = " " self-inductance of 1^{st} coil.

L_2 = " " " " 2^{nd} coil.

then self induced emf in 1st coil is $(e_1) = -L_1 \frac{di}{dt}$

Ily " " " " 2nd " " $(e_2) = -L_2 \frac{di}{dt}$

Now,

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dt

Now,

Mutually-induced e.m.f in 1st coil due to change of current in 2nd coil is $(e_1') = -M\frac{di}{dt}$

Similarly

Mutually-induced e.m.f in 2nd coil due to change of current in 1st coil i.e $(e_2') = -M\frac{di}{dt}$

All voltage are of same sign.

Total induced e.m.f for this series combination is $= -\frac{di}{dt}[L_1 + L_2 + M + M]$

$= -\frac{di}{dt}[L_1 + L_2 + 2M]$ ——— (i)

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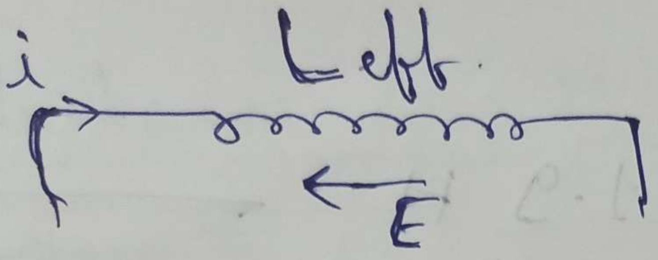

If Leff is the equivalent inductance of this series combination then we have

$$E = -L_{eff}\frac{di}{dt} \quad \text{———} \quad (ii)$$

from (i) & (ii) we have

$$-L_{eff}\frac{di}{dt} = -[L_1 + L_2 + 2M]\frac{di}{dt}$$

So, $L_{eff} = [L_1 + L_2 + 2M]$

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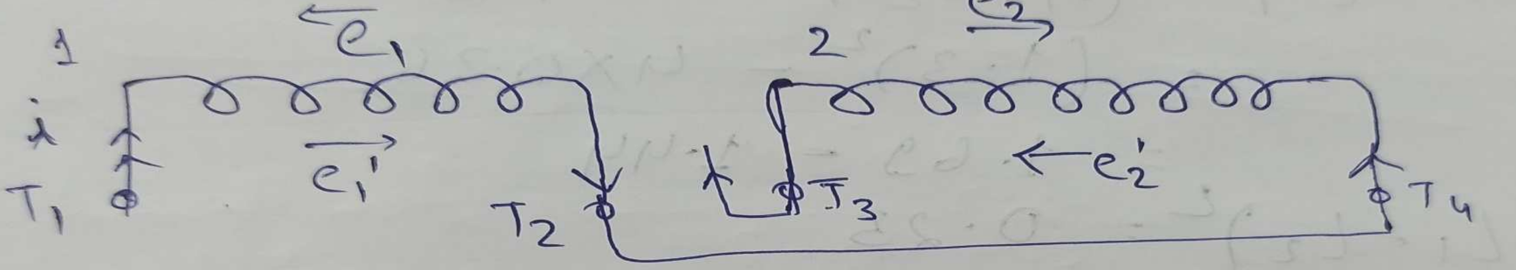
Case 2

When the coils are so joined that their fluxes are in opposite directions. as shown below.



So, like earlier

$$e_1 = -L_1 \frac{di}{dt} \quad \& \quad e_2 = -L_2 \frac{di}{dt}$$

$$e_1' = M \frac{di}{dt} \qquad e_2' = M \frac{di}{dt}$$

Total induced emf $= -\frac{di}{dt}\left[L_1 + L_2 - 2M\right]$

So, $\underline{L_{eff} = L_1 + L_2 - 2M}$ when m.m.f.s are subtractive

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Example 7.27. *Two coils with a coefficient of coupling of 0.5 between them, are connected in series so as to magnetise (a) in the same direction (b) in the opposite direction. The corresponding values of total inductances are for (a) 1.9 H and for (b) 0.7 H. Find the self-inductances of the two coils and the mutual inductance between them.*

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Soln. (a) $L_s = L_1 + L_2 + 2M = 1.9\ H$ —— i

$L_o = L_1 + L_2 - 2M = 0.7\ H$ —— (i)

Subtracting eqn. (ii) from (i) we get

$4M = 1.2\ H \Rightarrow M = 0.3\ H$

So, $L_1 + L_2 = 1.3\ H$ —— (iii)

$M = k\sqrt{L_1 L_2}$; k = co-efficient of coupling

$0.3 = 0.5\sqrt{L_1 L_2}$

$L_1 L_2 = \left(\frac{0.3}{0.5}\right)^2 = \frac{9}{25} = 0.36$

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$$(L_1 - L_2)^2 = (L_1 + L_2)^2 - 4L_1L_2$$

$$= (1.3)^2 - 4 \times 0.36$$

$$= 1.69 - 1.44$$

$$(L_1 - L_2)^2 = 0.25$$

$$L_1 - L_2 = 0.5\ H \quad \text{——— (iv)}$$

Adding (iii) & (iv) given

$$L_1 = 0.9\ H$$

then $L_2 = \underline{\underline{0.4\ H}}$

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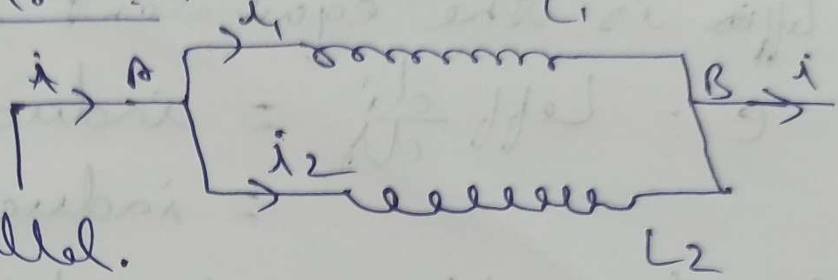
Inductance in ||el :→



~~In fig.~~

Two inductance are connected in parallel.

The co-efficient of mutual inductance between the two ~~L's~~ M. 'i' is the main current and i_1 is current through L_1 & i_2 is current through L_2.

So, $i = i_1 + i_2$

$$\frac{di}{dt} = \frac{di_1}{dt} + \frac{di_2}{dt} \quad \text{—(i)}$$ [Differentiating both side]

Since the coils are in ||el so the total emf induced in each coil are equal i.e. e then,

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If L_{eff} is the equivalent inductance then.

$$e = L_{eff}\frac{di}{dt} = \text{induced emf in the } \parallel^{l} \text{ combination}$$

$$= \text{induced emf. in any one coil}$$

$$L_{eff}\frac{di}{dt} = L_1\frac{di_1}{dt} + M\frac{di_2}{dt}$$

$$\text{or, } \frac{di}{dt} = \frac{1}{L}\left(L_1\frac{di_1}{dt} + M\frac{di_2}{dt}\right)$$

$$\text{or, } \frac{di}{dt} = \frac{1}{L}\left[L_1\left(\frac{L_2-M}{L_1-M}\right) + M\right]\frac{di_2}{dt} \quad \text{---(iv)}$$

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Equating eqn. (ii) and (iii) we get

$$\frac{L_2 - M}{L_1 - M} + 1 = \frac{1}{L}\left[L_1 \frac{(L_2 - M)}{(L_1 - M)} + M \right]$$

$$\frac{L_1 + L_2 - 2M}{\cancel{(L_1 - M)}} = \frac{1}{L}\left[\frac{L_1 L_2 \cancel{- L_1 M} \cancel{+ L_1 M} - M^2}{\cancel{(L_1 - M)}} \right]$$

$$L = \frac{L_1 L_2 - M^2}{L_1 + L_2 - 2M}$$ when ~~f~~ mmf's are additive.

and $$L = \frac{L_1 L_2 - M^2}{L_1 + L_2 + 2M}$$ when 2 fields oppose each other.

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For any query contact- 9771474020

Thank You

To be Contd..