(1)

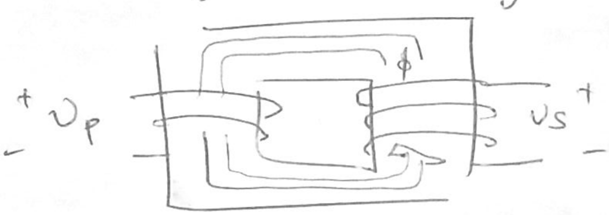
$\frac{d}{dt}$: $\lambda = N\phi = L i$

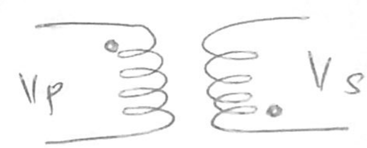
$$\frac{d\lambda}{dt} = N\frac{d\phi}{dt} = L\frac{di}{dt}$$

$$v = \frac{d\lambda}{dt} = N\frac{d\phi}{dt} = L\frac{di}{dt}$$

lenzs law gives direction to the produced voltage

- Voltage is produced by change in ϕ or i
- ϕ is magnetic change, i is electric change.





$$V_p = \frac{N_1 d\phi_1}{dt} = L\frac{di_1}{dt}$$

$$V_s = \frac{N_2 d\phi_1}{dt}$$ no i_2 so no ϕ_2 N_2 = Coils of 2nd

$N_1\phi_1 = L_1 i_1$ $\therefore$ $\phi = {}^{1}/_{N}L_1 i$

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

$$\phi_1 = \frac{L i_1}{N_1}$$

$$V_s = N_2\frac{d(L i_1)}{N_1\, dt}$$

M_{21} = Mutual ind in 2 due to 1 (current in 1) i_1

$$V_s = \frac{N_2 L}{N}\frac{di_1}{dt}$$

$$X_{M_{21}} = j\omega M_{21}$$

$$V_s = M_{21}\frac{di_1}{dt}$$

when fully coupled

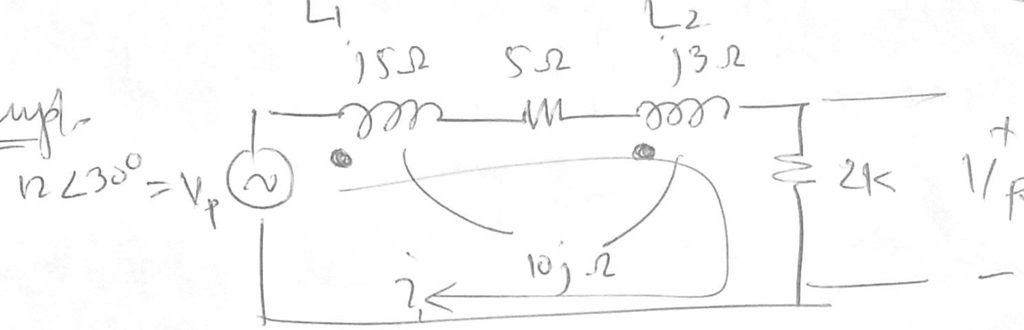
$$|M_{21}| = |M_{12}|$$

M_{ij} can be +ve or negative $\underline{j = \text{from}}$, $\underline{i = \text{in}}$

▷ Dot Notation Rules

- Dot not present, no induction in mutual
- Leaving current from dot on both coils (+ve)
- Entering " in " " " " (+ve)
- one leaving, other entering (negative).

Example.



Find V_R

Using KCL

$V_{in} = V_{out} + V_{drop}$

$V_{in} = V_{out} + V_{separate} + V_{mutual}$ (in each)

$12\angle 30^\circ = i_1(5 + 2k + 5j + 3j) + \overbrace{i_1(10j)}^{\text{in } L_1} + \overbrace{i_1(10j)}^{\text{in } L_2}$

$12\angle 30^\circ = i_1(2005 + j28)$

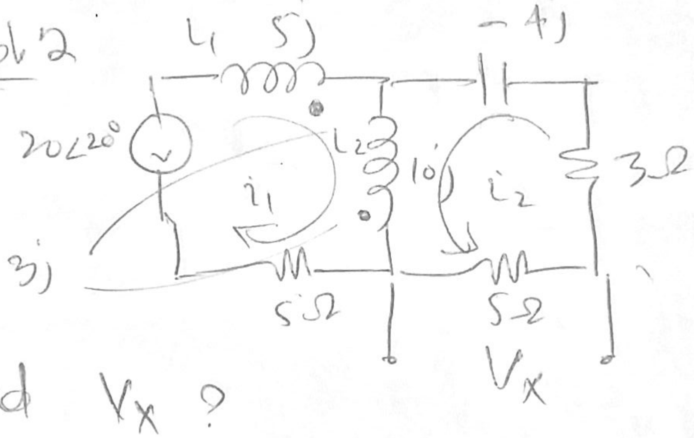
$i_1 = \dfrac{12\angle 30^\circ}{2005 + j28} = \dfrac{12\angle 30^\circ}{2005.19\angle 0.8^\circ}$

$i_1 = 5.99\angle 29.18^\circ$

$V_R = i_1 R = 2k(5.99\angle 29.18^\circ)$

$\boxed{V_R = 11.96\angle 29.18^\circ \text{ volts}}$

Exampl 2



Find V_x ?

i_1:

$$20\angle 20^\circ = i_1(5j+10j+5) + i_2(10j) \quad (\text{without } L_1, L_2 \ M)$$

$$20\angle 20^\circ = i_1(15j+5) + i_2(10j) + \overbrace{i_1(10j)}^{\text{in } L_2 \text{ dt } 1} + \overbrace{(i_1+i_2)(10j)}^{\text{in } L_1 \text{ dt } I}$$

$$20\angle 30^\circ = i_1(5+45j) + i_2(20j) \quad \text{——— } (1)$$

i_2:

$$0 = i_1(10j) + i_2(10j - 4j + 3 + 5) \quad (\text{with } L \ M)$$

$$0 = i_1(10j) + i_2(8+6j) + \overbrace{i_1(10j)}^{\text{in } L_2 \text{ due to(dt) } i_1}$$

$$0 = i_1(20j) + i_2(8+6j) \quad \text{——— } (2)$$

$$i_1 = \frac{-i_2(8+6j)}{20j}$$

$$20\angle 30^\circ = \frac{-i_2(8+6j)}{20j} + i_2(20j)$$

$$400\angle 120^\circ = -i_2(8+6j) - 400\,i_2$$

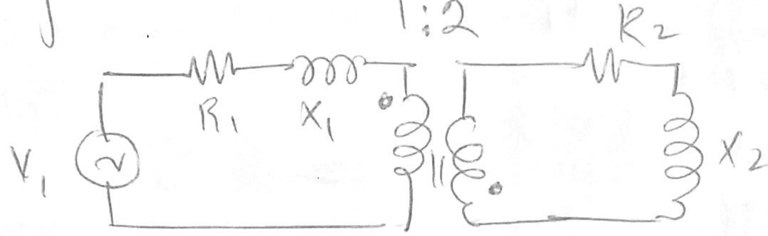
$$400\angle 120^\circ = -i_2(-392+6j)$$

$$i_2 = \frac{-400\angle 120^\circ}{-392+6j} = \frac{\not{-}400\angle 120^\circ}{\not{-}392.04\angle 179.1^\circ}$$

$$i_2 = 1.0204\angle -59.1^\circ$$

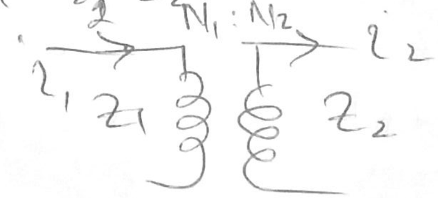
$$V_x = 5(1.02\angle -59.1^\circ) = 5.1\angle 59.1^\circ \text{ volts.}$$

▷ Impedance Conversion;



$P_1 = P_2$ // $S_1 = S_2$

$I_1^2 Z_1 = I_2^2 Z_2$



$$\frac{I_1}{I_2} = \frac{N_2}{N_1} = \frac{V_2}{V_1}$$

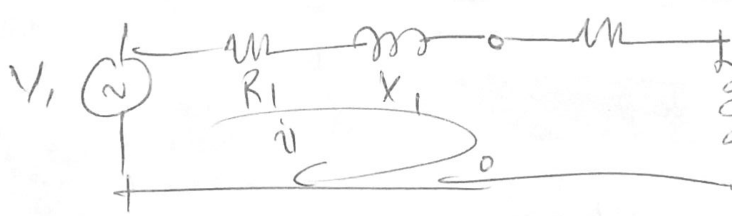
$$\frac{I_1^2}{I_2^2} = \frac{Z_2}{Z_1} = \frac{N_2^2}{N_1^2}$$

$$Z_1 = Z_2\left(\frac{N_1^2}{N_2^2}\right) = Z_2\left(\frac{N_1}{N_2}\right)^2 = Z_2(TR)^2$$

Thus step up transformer makes secondary resistance lesser (visibility will be less) on primary side.

Circuit will become:

$\left(\frac{N_1}{N_2}\right)^2 \times R_2$



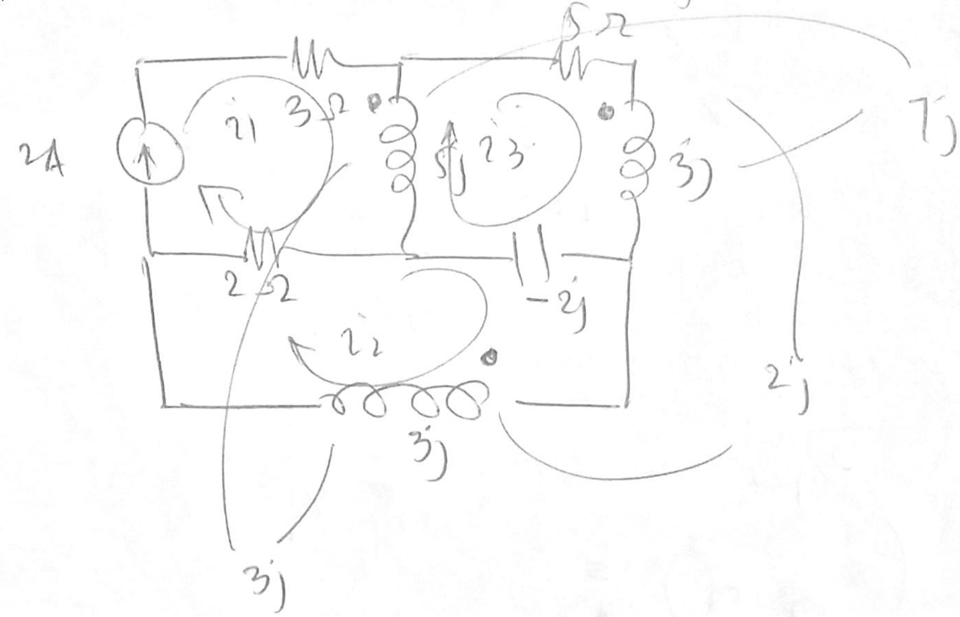
$X_2\left(\frac{N_1}{N_2}\right)^2 = X_2(a)^2$

Now you can solve it as single loop equation.

$$V_1 = i_1(R_1 + X_1 + a^2R_2 + a^2X_2)$$

Write Current equations for following coupled CKt

3



$i_1 = 2A$ ——— (1)

$0 = i_1(3+5j+2) - i_2(2) - i_3(5j)$
$\quad + i_2(3j) - i_3(7j)$

i_1: $0 = i_1(5+5j) + i_2(3j-2) + i_3(-12j)$ ——— (2)

i_2: $0 = i_2(2+3j-2j) - i_1(2) + i_3(+2j)$
$\quad + (i_1 - i_3)(3j) + i_3(2j)$

$0 = i_1(3j-2) + i_2(2+j) + i_3(1j)$ ——— (3)

i_3: $0 = -i_1(5j) + i_2(+2j) + i_3(5+6j)$
$\quad + 7j(i_1 - i_3) + 2j(i_2) - 7j(i_3) + 2j(i_2)$

$0 = i_1(-5j+7j) + i_2(2j+2j+2j) + i_3(5+6j-7j-7j)$

$0 = i_1(2j) + i_2(6j) + i_3(5+8j)$ ——— (4)