

CAP13 – TABELAS E FIGURAS

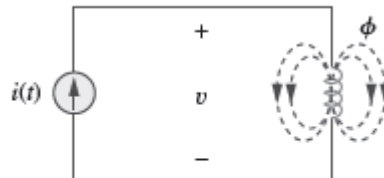


Figura 13.1 Fluxo magnético produzido por uma única bobina com N espiras.

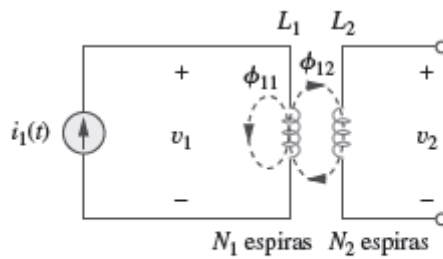


Figura 13.2 Indutância mútua M_{21} da bobina 2 em relação à bobina 1.

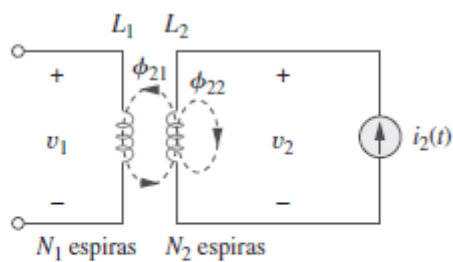


Figura 13.3 Indutância mútua M_{12} da bobina 1 em relação à bobina 2.

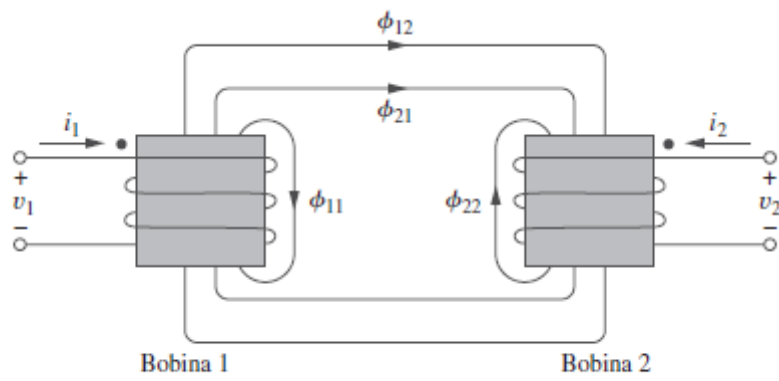


Figura 13.4 Ilustração da convenção do ponto.

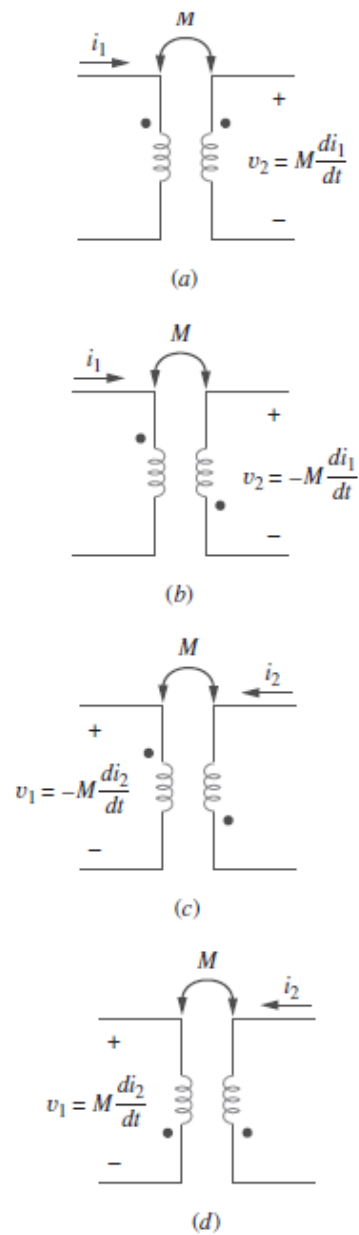


Figura 13.5 Exemplos ilustrando como aplicar a convenção do ponto.

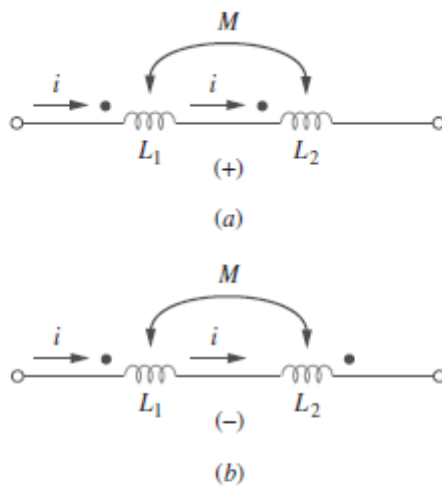


Figura 13.6 Convenção do ponto para bobinas em série; o sinal indica a polaridade da tensão mútua: (a) conexão série aditiva; (b) conexão série subtrativa.

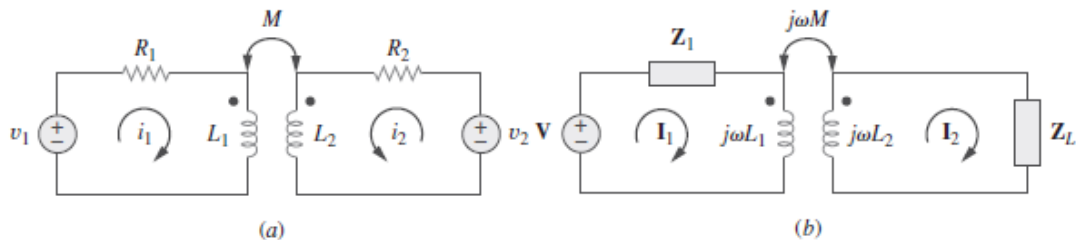


Figura 13.7 (a) Análise no domínio do tempo de um circuito contendo bobinas acopladas; (b) análise no domínio da frequência de um circuito contendo bobinas acopladas.

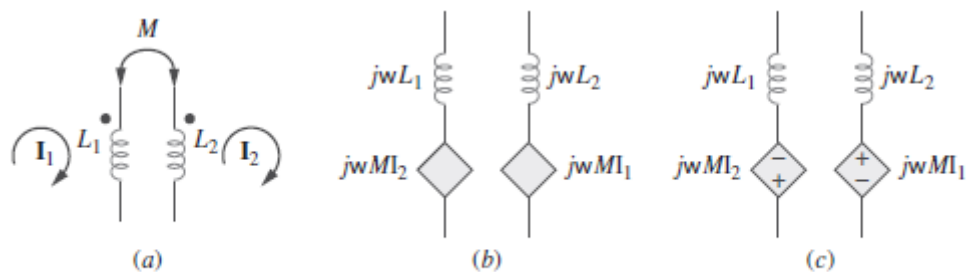


Figura 13.8 Modelo que torna mais fácil a análise de circuitos mutuamente acoplados.

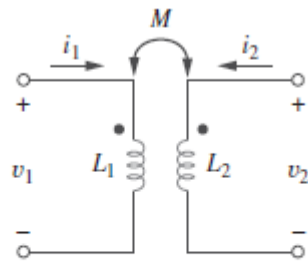


Figura 13.14 Circuito para derivação de energia armazenada em um circuito acoplado.

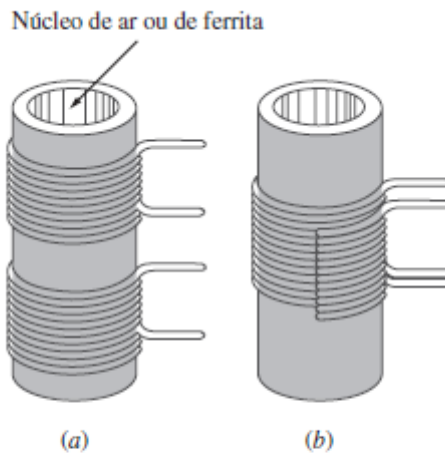


Figura 13.15 Enrolamentos:
 (a) livremente acoplados;
 (b) firmemente acoplados;
 a vista em corte transversal demonstra ambos os enrolamentos.

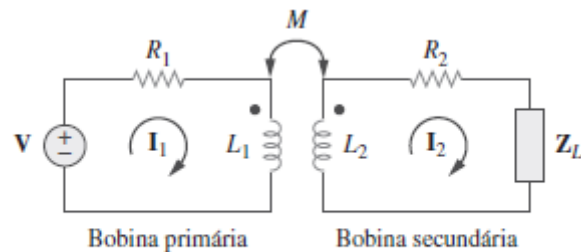


Figura 13.19 Transformador linear.

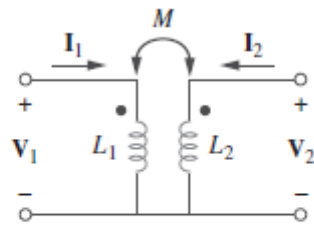


Figura 13.21 Determinação do circuito equivalente de um transformador linear.

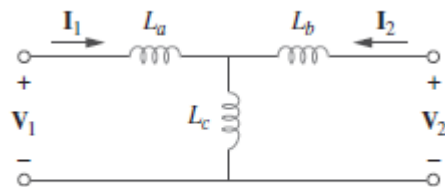


Figura 13.22 Circuito T equivalente.

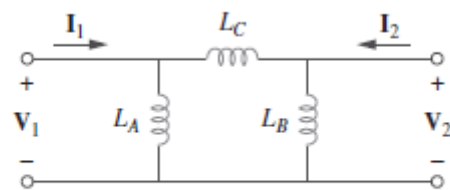
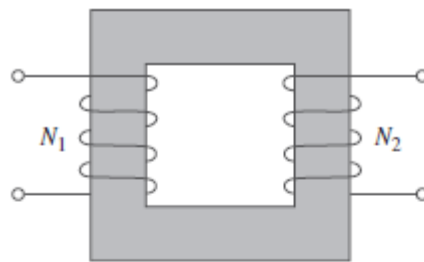
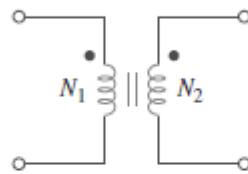


Figura 13.23 Circuito \$\Pi\$ equivalente.



(a)



(b)

Figura 13.30 (a) Transformador ideal; (b) símbolo usado em circuitos para transformadores ideais.

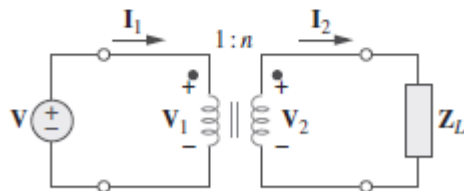
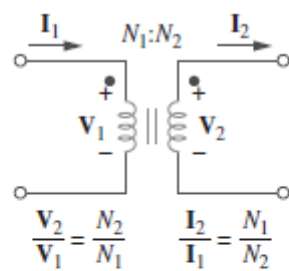
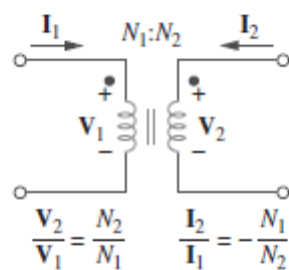


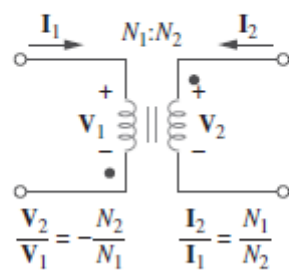
Figura 13.31 Relacionando valores primário e secundário em um transformador ideal.



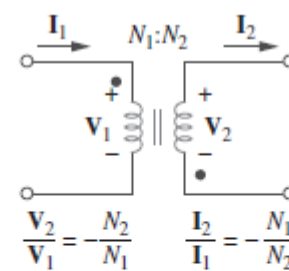
(a)



(b)



(c)



(d)

Figura 13.32 Circuitos típicos ilustrando as polaridades das tensões, bem como os sentidos das correntes apropriados em um transformador ideal.

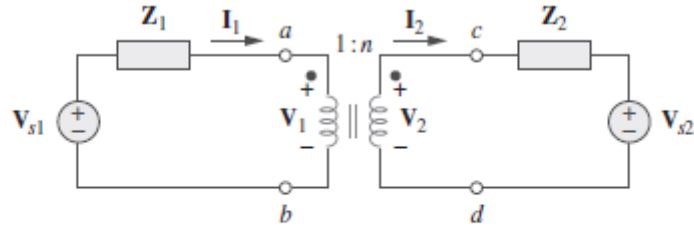


Figura 13.33 Circuito de transformador ideal cujos circuitos equivalentes devem ser encontrados.

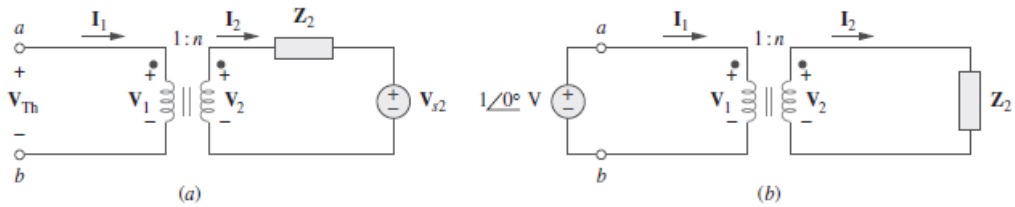


Figura 13.34 (a) Obtenção de V_{Th} para o circuito da Figura 13.33; (b) obtenção de Z_{Th} para o circuito da Figura 13.33.

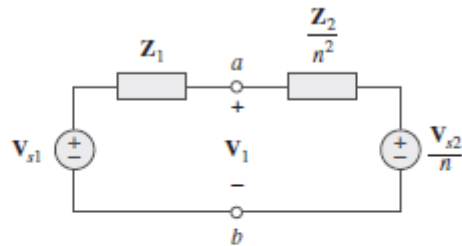


Figura 13.35 Circuito equivalente para a Figura 13.33 obtido refletindo-se o circuito do secundário para o lado do primário.

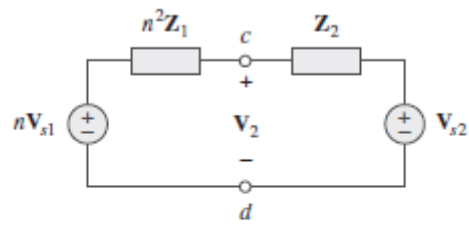
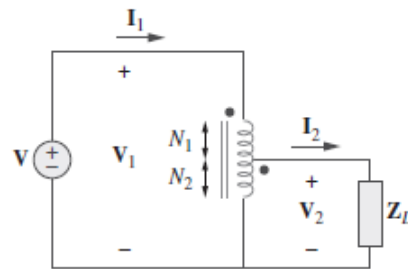


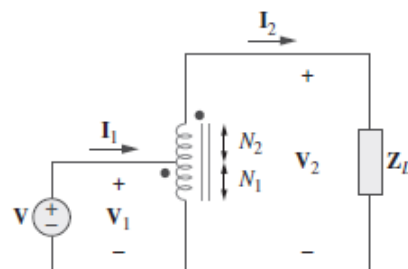
Figura 13.36 Circuito equivalente para a Figura 13.33 obtido refletindo-se o circuito do primário para o lado do secundário.



Figura 13.41 Autotransformador-padrão. (Cortesia de Todd Systems Inc.)



(a)



(b)

Figura 13.42 (a) Autotransformador abaixador; (b) autotransformador elevador.

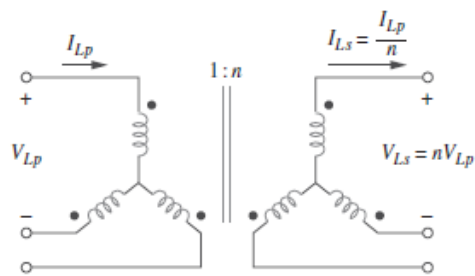


Figura 13.46 Conexão estrela-estrela de um transformador trifásico.

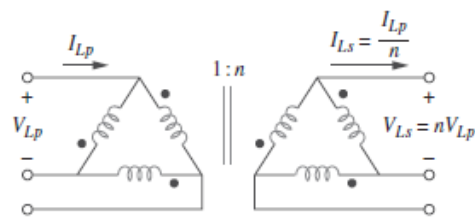


Figura 13.47 Conexão triângulo-triângulo de um transformador trifásico.

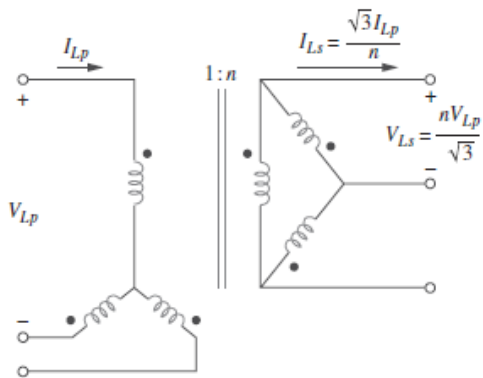


Figura 13.48 Conexão estrela-triângulo de um transformador trifásico.

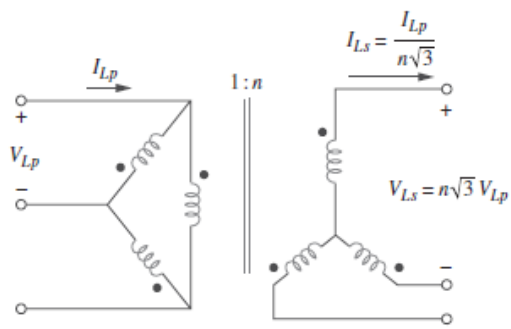


Figura 13.49 Conexão triângulo-estrela de um transformador trifásico.

RESOLUÇÃO DE EXERCÍCIOS

13.11 Use a análise de malhas para determinar i_x na Figura 13.80, onde $i_s = 4 \cos(600t)$ A e $v_s = 110 \cos(600t + 30^\circ)$ V.

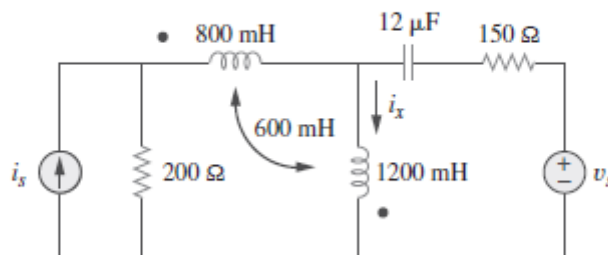
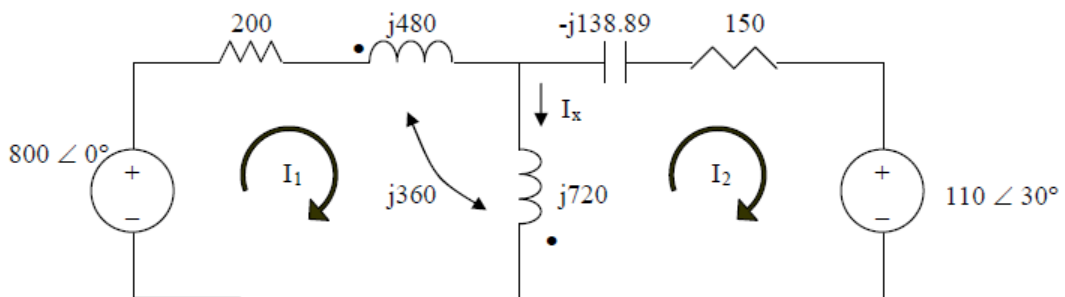


Figura 13.80 Esquema para o Problema 13.11.

$$\begin{aligned}
 800\text{mH} &\longrightarrow j\omega L = j600 \times 800 \times 10^{-3} = j480 \\
 600\text{mH} &\longrightarrow j\omega L = j600 \times 600 \times 10^{-3} = j360 \\
 1200\text{mH} &\longrightarrow j\omega L = j600 \times 1200 \times 10^{-3} = j720 \\
 12\mu\text{F} &\longrightarrow \frac{1}{j\omega C} = \frac{-j}{600 \times 12 \times 10^{-6}} = -j138.89
 \end{aligned}$$

After transforming the current source to a voltage source, we get the circuit shown below.



For mesh 1,

$$\begin{aligned}800 &= (200 + j480 + j720)I_1 + j360I_2 - j720I_2 \text{ or} \\800 &= (200 + j1200)I_1 - j360I_2\end{aligned}\quad (1)$$

For mesh 2,

$$\begin{aligned}110\angle 30^\circ + 150 - j138.89 + j720I_2 + j360I_1 &= 0 \text{ or} \\-95.2628 - j55 &= -j360I_1 + (150 + j581.1)I_2\end{aligned}\quad (2)$$

In matrix form,

$$\begin{bmatrix} 800 \\ -95.2628 - j55 \end{bmatrix} = \begin{bmatrix} 200 + j1200 & -j360 \\ -j360 & 150 + j581.1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

Solving this using MATLAB leads to:

```
>> Z = [(200+1200i),-360i;-360i,(150+581.1i)]
Z =
1.0e+003 *
0.2000 + 1.2000i    0 - 0.3600i
```

```
0 - 0.3600i    0.1500 + 0.5811i
>> V = [800;(-95.26-55i)]
```

```
V =
1.0e+002 *
8.0000
-0.9526 - 0.5500i
```

```
>> I = inv(Z)*V
I =
0.1390 - 0.7242i
0.0609 - 0.2690i
```

$$I_x = I_1 - I_2 = 0.0781 - j0.4552 = 0.4619\angle -80.26^\circ.$$

Hence,

$$i_x(t) = 461.9\cos(600t - 80.26^\circ) \text{ mA.}$$

13.14 Obtenha o circuito equivalente de Thévenin para o circuito da Figura 13.83 nos terminais a - b .

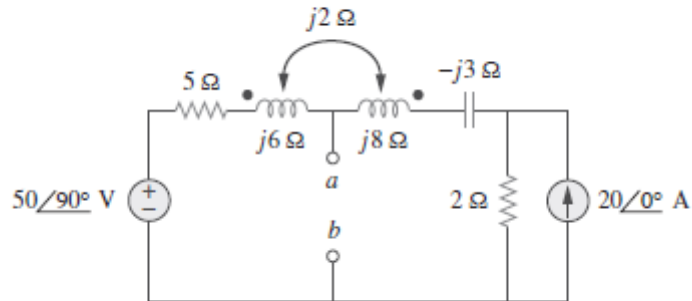
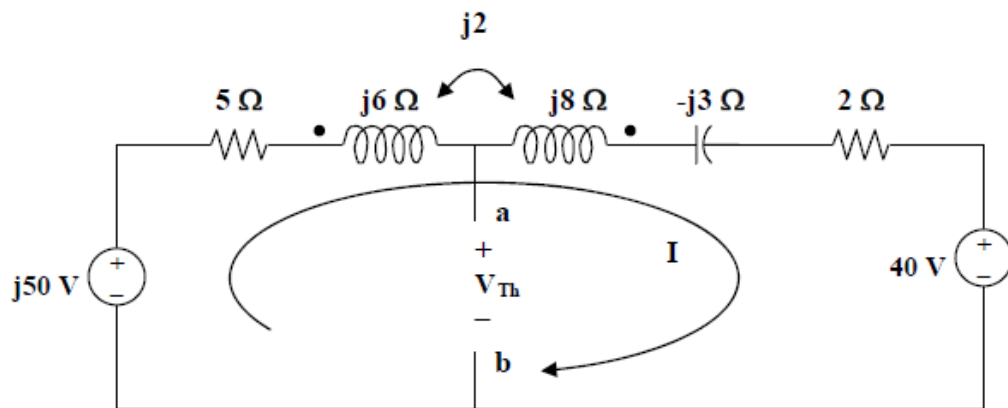


Figura 13.83 Esquema para o Problema 13.14.

To obtain V_{Th} , convert the current source to a voltage source as shown below.



Note that the two coils are connected series aiding.

$$\omega L = \omega L_1 + \omega L_2 - 2\omega M$$

$$j\omega L = j6 + j8 - j4 = j10$$

Thus,
$$-j50 + (5 + j10 - j3 + 2)I + 40 = 0$$

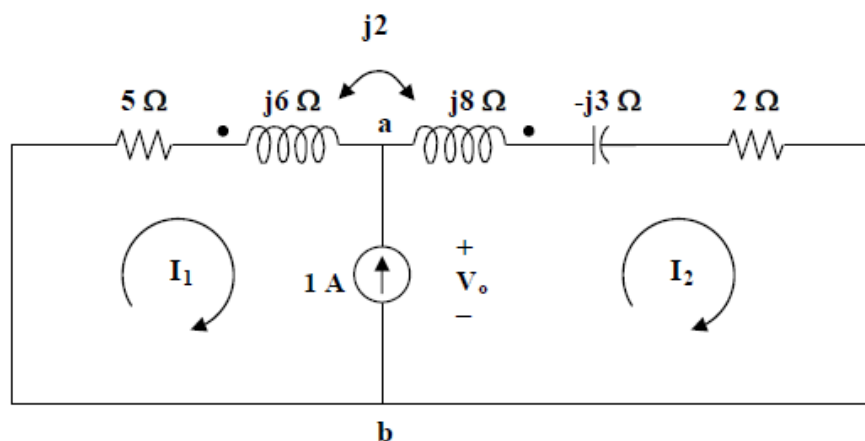
$$I = (-40 + j50)/(7 + j7)$$

But,
$$-j50 + (5 + j6)I - j2I + V_{Th} = 0$$

$$V_{Th} = j50 - (5 + j4)I = j50 - (5 + j4)(-40 + j50)/(7 + j7)$$

$$V_{Th} = 26.74\angle 34.11^\circ \text{ V}$$

To obtain Z_{Th} , we set all the sources to zero and insert a 1-A current source at the terminals a-b as shown below.



Clearly, we now have only a super mesh to analyze.

$$(5 + j6)I_1 - j2I_2 + (2 + j8 - j3)I_2 - j2I_1 = 0$$

$$(5 + j4)I_1 + (2 + j3)I_2 = 0 \quad (1)$$

But, $I_2 - I_1 = 1$ or $I_2 = I_1 + 1$ (2)

Substituting (2) into (1), $(5 + j4)I_1 + (2 + j3)(1 + I_1) = 0$

$$I_1 = -(2 + j3)/(7 + j7)$$

Now, $((5 + j6)I_1 - j2I_1 + V_o = 0$

$$V_o = -(5 + j4)I_1 = (5 + j4)(2 + j3)/(7 + j7) = (-2 + j23)/(7 + j7) = 2.332\angle 50^\circ$$

$$Z_{Th} = V_o/1 = 2.332\angle 50^\circ \Omega$$

13.16 Obtenha o equivalente de Norton nos terminais a - b do circuito da Figura 13.85.

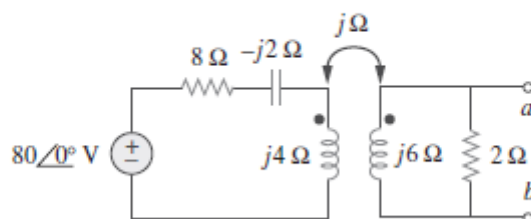
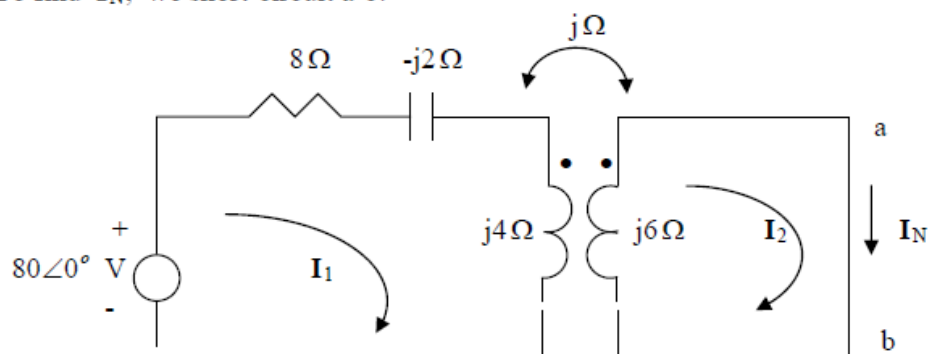


Figura 13.85 Esquema para o Problema 13.16.

To find I_N , we short-circuit a - b .



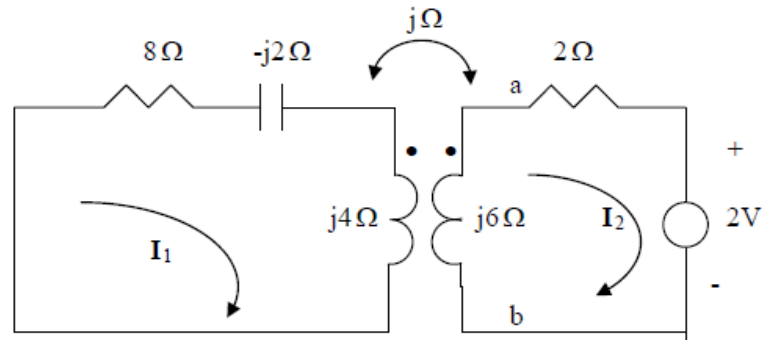
$$-80 + (8 - j2 + j4)I_1 - jI_2 = 0 \quad \longrightarrow \quad (8 + j2)I_1 - jI_2 = 80 \quad (1)$$

$$j6I_2 - jI_1 = 0 \quad \longrightarrow \quad I_1 = 6I_2 \quad (2)$$

Solving (1) and (2) leads to

$$I_N = I_2 = \frac{80}{48 + j1} = 1.584 - j0.362 = 1.6246\angle -12.91^\circ \text{ A}$$

To find Z_N , insert a 1-A current source at terminals a-b. Transforming the current source to voltage source gives the circuit below.



$$0 = (8 + j2)I_1 - jI_2 \quad \longrightarrow \quad I_1 = \frac{jI_2}{8 + j2}$$

$$= [j/(8.24621 \angle 14.036^\circ)]I_2 = 0.121268 \angle 75.964^\circ I_2$$

$$= (0.0294113 + j0.117647)I_2 \quad (3)$$

$$2 + (2 + j6)I_2 - jI_1 = 0 \quad (4)$$

Solving (3) and (4) leads to $(2 + j6)I_2 - j(0.0294113 + j0.117647)I_2 = -2$ or

$$(2.117647 + j5.882353)I_2 = -2 \text{ or } I_2 = -2/(6.25192 \angle 70.201^\circ) = 0.319902 \angle 109.8^\circ.$$

$$V_{ab} = 2(1 + I_2) = 2(1 - 0.1083629 + j0.30099) = (1.78327 + j0.601979) \text{ V} = 1Z_{eq} \text{ or}$$

$$Z_{eq} = (1.78327 + j0.601979) = 1.8821 \angle 18.65^\circ \Omega$$

An alternate approach would be to calculate the open circuit voltage.

$$-80 + (8+j2)\mathbf{I}_1 - j\mathbf{I}_2 = 0 \text{ or } (8+j2)\mathbf{I}_1 - j\mathbf{I}_2 = 80 \quad (5)$$

$$(2+j6)\mathbf{I}_2 - j\mathbf{I}_1 = 0 \text{ or } \mathbf{I}_1 = (2+j6)\mathbf{I}_2/j = (6-j2)\mathbf{I}_2 \quad (6)$$

Substituting (6) into (5) we get,

$$(8.24621\angle 14.036^\circ)(6.32456\angle -18.435^\circ)\mathbf{I}_2 - j\mathbf{I}_2 = 80 \text{ or}$$

$$[(52.1536\angle -4.399^\circ) - j]\mathbf{I}_2 = [52 - j5]\mathbf{I}_2 = (52.2398\angle -5.492^\circ)\mathbf{I}_2 = 80 \text{ or}$$

$$\mathbf{I}_2 = 1.5314\angle 5.492^\circ \text{ A and } V_{oc} = 2\mathbf{I}_2 = 3.0628\angle 5.492^\circ \text{ V which leads to,}$$

$$Z_{eq} = V_{oc}/I_{sc} = (3.0628\angle 5.492^\circ)/(1.6246\angle -12.91^\circ) = \mathbf{1.8853\angle 18.4^\circ \Omega}$$

This is in good agreement with what we determined before.

* 13.22 Determine a corrente I_o no circuito da Figura 13.91.

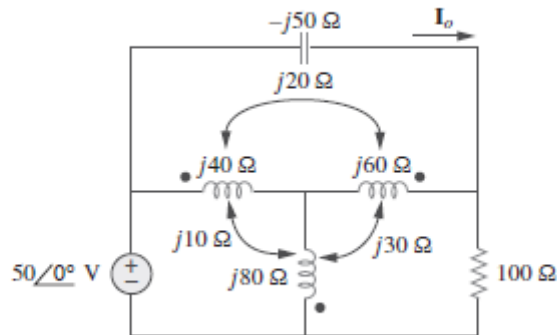
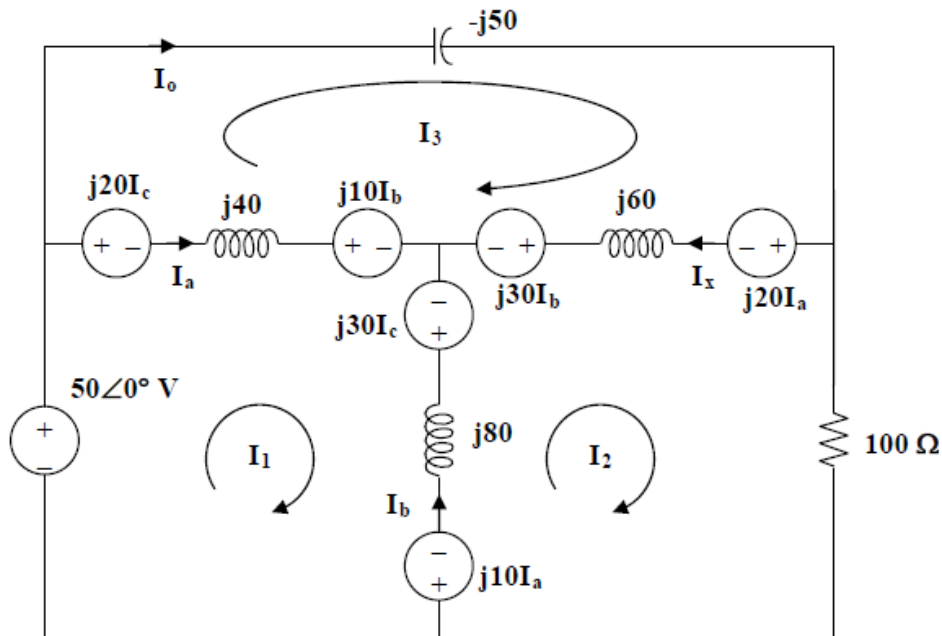


Figura 13.91 Esquema para o Problema 13.22.

With more complex mutually coupled circuits, it may be easier to show the effects of the coupling as sources in terms of currents that enter or leave the dot side of the coil. Figure 13.85 then becomes,



Note the following,

$$I_a = I_1 - I_3$$

$$I_b = I_2 - I_1$$

$$I_c = I_3 - I_2$$

$$\text{and } I_o = I_3$$

Now all we need to do is to write the mesh equations and to solve for I_o .

Loop # 1,

$$-50 + j20(I_3 - I_2) + j40(I_1 - I_3) + j10(I_2 - I_1) - j30(I_3 - I_2) + j80(I_1 - I_2) - j10(I_1 - I_3) = 0$$

$$j100I_1 - j60I_2 - j40I_3 = 50$$

$$\text{Multiplying everything by } (1/j10) \text{ yields } 10I_1 - 6I_2 - 4I_3 = -j5 \quad (1)$$

Loop # 2,

$$j10(I_1 - I_3) + j80(I_2 - I_1) + j30(I_3 - I_2) - j30(I_2 - I_1) + j60(I_2 - I_3) - j20(I_1 - I_3) + 100I_2 = 0$$

$$-j60I_1 + (100 + j80)I_2 - j20I_3 = 0 \quad (2)$$

Loop # 3,

$$-j50I_3 + j20(I_1 - I_3) + j60(I_3 - I_2) + j30(I_2 - I_1) - j10(I_2 - I_1) + j40(I_3 - I_1) - j20(I_3 - I_2) = 0$$

$$-j40I_1 - j20I_2 + j10I_3 = 0$$

$$\text{Multiplying by } (1/j10) \text{ yields, } -4I_1 - 2I_2 + I_3 = 0 \quad (3)$$

$$\text{Multiplying (2) by } (1/j20) \text{ yields } -3I_1 + (4 - j5)I_2 - I_3 = 0 \quad (4)$$

$$\text{Multiplying (3) by } (1/4) \text{ yields } -I_1 - 0.5I_2 - 0.25I_3 = 0 \quad (5)$$

$$\text{Multiplying (4) by } (-1/3) \text{ yields } I_1 - ((4/3) - j(5/3))I_2 + (1/3)I_3 = -j0.5 \quad (7)$$

$$\text{Multiplying [(6)+(5)] by 12 yields } (-22 + j20)I_2 + 7I_3 = 0 \quad (8)$$

$$\text{Multiplying [(5)+(7)] by 20 yields } -22I_2 - 3I_3 = -j10 \quad (9)$$

$$(8) \text{ leads to } I_2 = -7I_3 / (-22 + j20) = 0.2355 \angle 42.3^\circ = (0.17418 + j0.15849)I_3 \quad (10)$$

(9) leads to $I_3 = (j10 - 22I_2)/3$, substituting (1) into this equation produces,

$$I_3 = j3.333 + (-1.2273 - j1.1623)I_3$$

$$\text{or } I_3 = I_o = \mathbf{1.3040 \angle 63^\circ \text{ amp.}}$$

- * 13.28 No circuito da Figura 13.97, determine o valor de X que resultará na máxima transferência de potência para a carga de $20\ \Omega$.

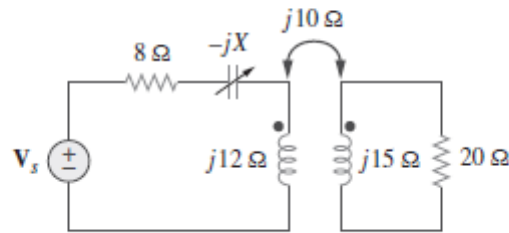
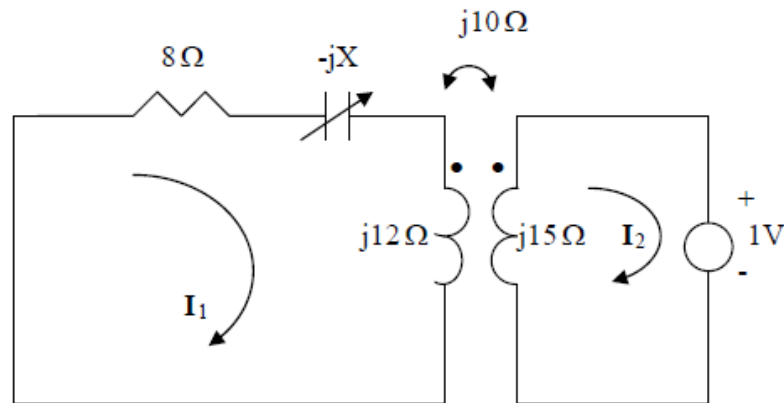


Figura 13.97 Esquema para o Problema 13.28.

We find Z_{Th} by replacing the 20-ohm load with a unit source as shown below.



For mesh 1, $0 = (8 - jX + j12)I_1 - j10I_2$ (1)

For mesh 2, $1 + j15I_2 - j10I_1 = 0 \longrightarrow I_1 = 1.5I_2 - 0.1j$ (2)

Substituting (2) into (1) leads to

$$I_2 = \frac{-1.2 + j0.8 + 0.1X}{12 + j8 - j1.5X}$$

$$Z_{Th} = \frac{1}{-I_2} = \frac{12 + j8 - j1.5X}{1.2 - j0.8 - 0.1X}$$

$$|Z_{Th}| = 20 = \frac{\sqrt{12^2 + (8 - 1.5X)^2}}{\sqrt{(1.2 - 0.1X)^2 + 0.8^2}} \longrightarrow 0 = 1.75X^2 + 72X - 624$$

Solving the quadratic equation yields $X = 6.425\ \Omega$

* 13.32 Dois transformadores lineares são colocados em cascata, conforme mostrado na Figura 13.101. Demonstre que

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$$Z_{\text{ent}} = \frac{\omega^2 R(L_a^2 + L_a L_b - M_a^2) + j\omega^3(L_a^2 L_b + L_a L_b^2 - L_a M_b^2 - L_b M_a^2)}{\omega^2(L_a L_b + L_b^2 - M_b^2) - j\omega R(L_a + L_b)}$$

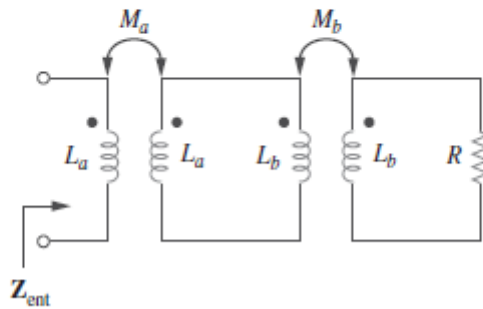
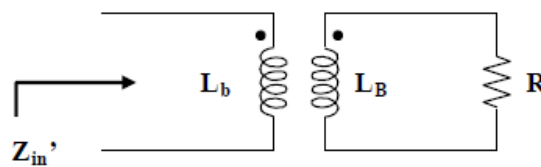


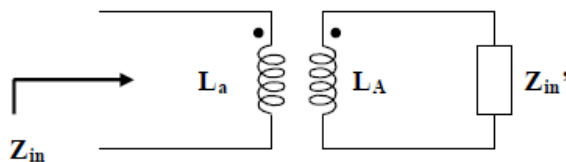
Figura 13.101 Esquema para o Problema 13.32.

We first find Z_{in} for the second stage using the concept of reflected impedance.



$$Z_{\text{in}}' = j\omega L_b + \omega^2 M_b^2 / (R + j\omega L_b) = (j\omega L_b R - \omega^2 L_b^2 + \omega^2 M_b^2) / (R + j\omega L_b) \quad (1)$$

For the first stage, we have the circuit below.



$$\begin{aligned}
Z_{in} &= j\omega L_a + \omega^2 M_a^2 / (j\omega L_a + Z_{in}) \\
&= (-\omega^2 L_a^2 + \omega^2 M_a^2 + j\omega L_a Z_{in}) / (j\omega L_a + Z_{in}) \quad (2)
\end{aligned}$$

Substituting (1) into (2) gives,

$$\begin{aligned}
&= \frac{-\omega^2 L_a^2 + \omega^2 M_a^2 + j\omega L_a \frac{(j\omega L_b R - \omega^2 L_b^2 + \omega^2 M_b^2)}{R + j\omega L_b}}{j\omega L_a + \frac{j\omega L_b R - \omega^2 L_b^2 + \omega^2 M_b^2}{R + j\omega L_b}} \\
&= \frac{-R\omega^2 L_a^2 + \omega^2 M_a^2 R - j\omega^3 L_b L_a + j\omega^3 L_b M_a^2 + j\omega L_a (j\omega L_b R - \omega^2 L_b^2 + \omega^2 M_b^2)}{j\omega R L_a - \omega^2 L_a L_b + j\omega L_b R - \omega^2 L_a^2 + \omega^2 M_b^2} \\
Z_{in} &= \frac{\omega^2 R (L_a^2 + L_a L_b - M_a^2) + j\omega^3 (L_a^2 L_b + L_a L_b^2 - L_a M_b^2 - L_b M_a^2)}{\omega^2 (L_a L_b + L_b^2 - M_b^2) - j\omega R (L_a + L_b)}
\end{aligned}$$

* 13.35 Determine as correntes I_1 , I_2 e I_3 no circuito da Figura

13.104.
ML

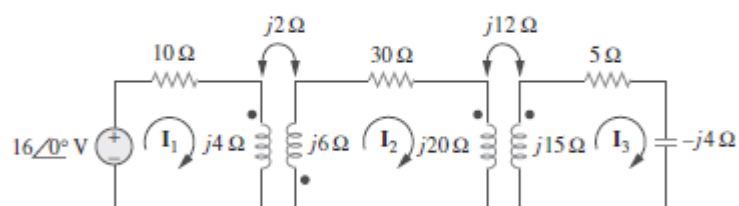


Figura 13.104 Esquema para o Problema 13.35.

For mesh 1,

$$16 = (10 + j4)I_1 + j2I_2 \quad (1)$$

For mesh 2,

$$0 = j2I_1 + (30 + j26)I_2 - j12I_3 \quad (2)$$

For mesh 3,

$$0 = -j12I_2 + (5 + j11)I_3 \quad (3)$$

We may use MATLAB to solve (1) to (3) and obtain

$$I_1 = 1.3736 - j0.5385 = 1.4754 \angle -21.41^\circ \text{ A}$$

$$I_2 = -0.0547 - j0.0549 = 77.5 \angle -134.85^\circ \text{ mA}$$

$$I_3 = -0.0268 - j0.0721 = 77 \angle -110.41^\circ \text{ mA}$$

1.4754∠-21.41° A, 77.5∠-134.85° mA, 77∠-110.41° mA

* 13.44 No circuito do transformador ideal da Figura 13.109, determine $i_1(t)$ e $i_2(t)$.

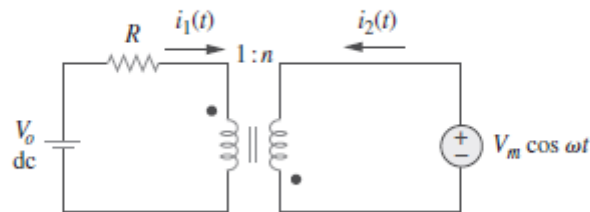
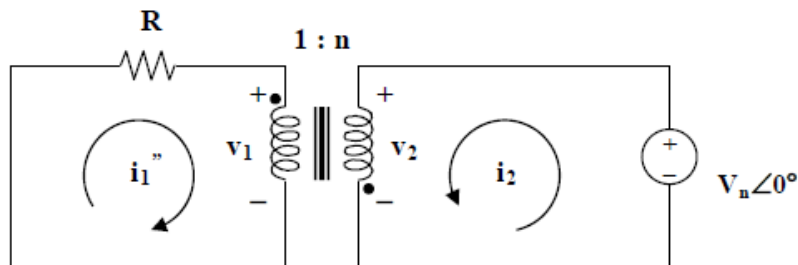


Figura 13.109 Esquema para o Problema 13.44.

We can apply the superposition theorem. Let $i_1 = i_1' + i_1''$ and $i_2 = i_2' + i_2''$ where the single prime is due to the DC source and the double prime is due to the AC source. Since we are looking for the steady-state values of i_1 and i_2 ,

$$i_1' = i_2' = 0.$$

For the AC source, consider the circuit below.



$$v_2/v_1 = -n, \quad I_2''/I_1'' = -1/n$$

But $v_2 = v_m$, $v_1 = -v_m/n$ or $I_1'' = v_m/(Rn)$

$$I_2'' = -I_1''/n = -v_m/(Rn^2)$$

Hence, $i_1(t) = (v_m/Rn)\cos\omega t$ A, and $i_2(t) = (-v_m/(n^2R))\cos\omega t$ A

* 13.61 Para o circuito da Figura 13.126, determine I_1 , I_2 e V_o .

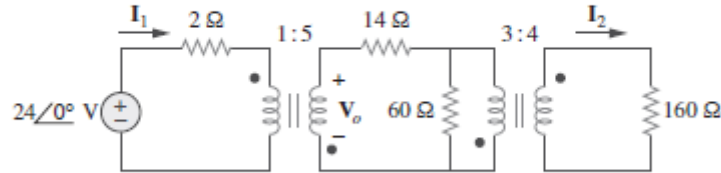
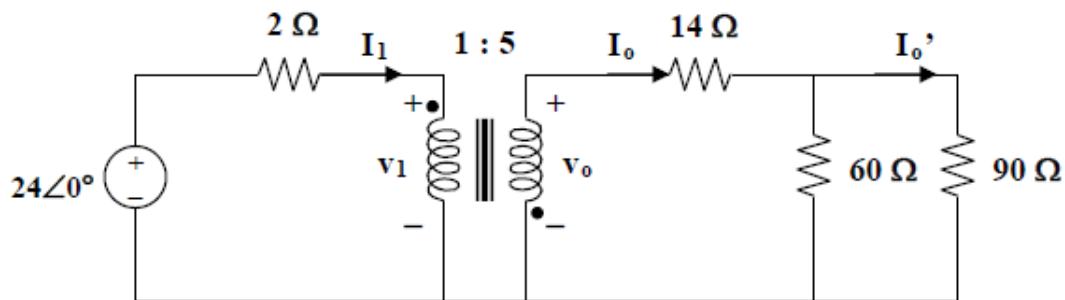


Figura 13.126 Esquema para o Problema 13.61.

We reflect the 160-ohm load to the middle circuit.

$$Z_R = Z_L/n^2 = 160/(4/3)^2 = 90 \text{ ohms, where } n = 4/3$$



$$14 + 60||90 = 14 + 36 = 50 \text{ ohms}$$

We reflect this to the primary side.

$$Z_R' = Z_L'/(n')^2 = 50/5^2 = 2 \text{ ohms when } n' = 5$$

$$I_1 = 24/(2 + 2) = 6 \text{ A}$$

$$24 = 2I_1 + v_1 \text{ or } v_1 = 24 - 2I_1 = 12 \text{ V}$$

$$v_o = -nv_1 = -60 \text{ V, } I_o = -I_1/n_1 = -6/5 = -1.2$$

$$I_o' = [60/(60 + 90)]I_o = -0.48 \text{ A}$$

$$I_2 = -I_o'/n = 0.48/(4/3) = 360 \text{ mA}$$

* 13.65 Calcule a potência média dissipada pelo resistor de $20\ \Omega$ na Figura 13.130.

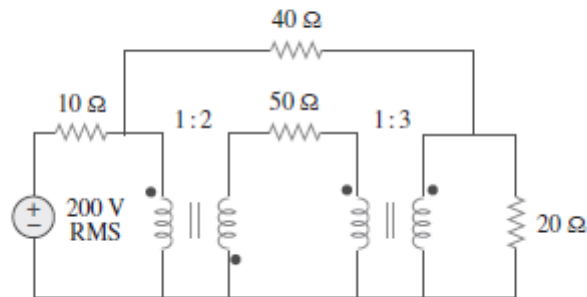
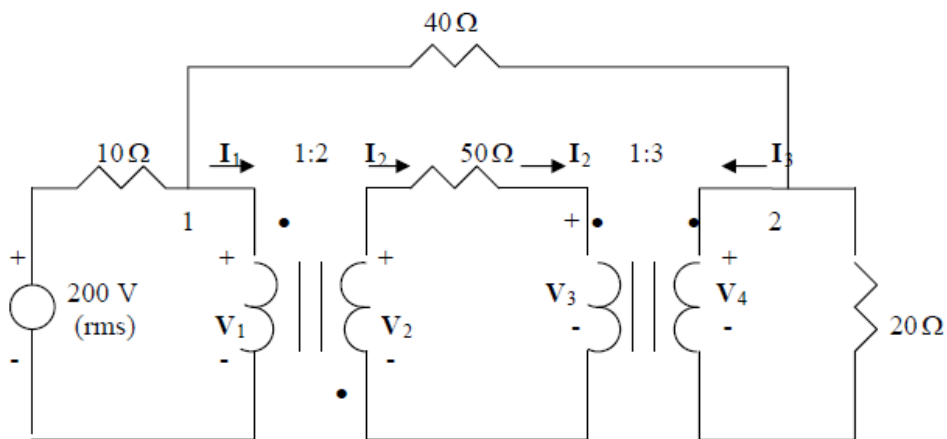


Figura 13.130 Esquema para o Problema 13.65.



At node 1,

$$\frac{200 - V_1}{10} = \frac{V_1 - V_4}{40} + I_1 \quad \longrightarrow \quad 200 = 1.25V_1 - 0.25V_4 + 10I_1 \quad (1)$$

At node 2,

$$\frac{V_1 - V_4}{40} = \frac{V_4}{20} + I_3 \quad \longrightarrow \quad V_1 = 3V_4 + 40I_3 \quad (2)$$

At the terminals of the first transformer,

$$\frac{V_2}{V_1} = -2 \quad \longrightarrow \quad V_2 = -2V_1 \quad (3)$$

$$\frac{I_2}{I_1} = -1/2 \quad \longrightarrow \quad I_1 = -2I_2 \quad (4)$$

For the middle loop,

$$-V_2 + 50I_2 + V_3 = 0 \quad \longrightarrow \quad V_3 = V_2 - 50I_2 \quad (5)$$

At the terminals of the second transformer,

$$\frac{V_4}{V_3} = 3 \quad \longrightarrow \quad V_4 = 3V_3 \quad (6)$$

$$\frac{I_3}{I_2} = -1/3 \quad \longrightarrow \quad I_2 = -3I_3 \quad (7)$$

We have seven equations and seven unknowns. Combining (1) and (2) leads to

$$200 = 3.5V_4 + 10I_1 + 50I_3$$

But from (4) and (7), $I_1 = -2I_2 = -2(-3I_3) = 6I_3$. Hence

$$200 = 3.5V_4 + 110I_3 \quad (8)$$

From (5), (6), (3), and (7),

$$V_4 = 3(V_2 - 50I_2) = 3V_2 - 150I_2 = -6V_1 + 450I_3$$

Substituting for V_1 in (2) gives

$$V_4 = -6(3V_4 + 40I_3) + 450I_3 \quad \longrightarrow \quad I_3 = \frac{19}{210}V_4 \quad (9)$$

Substituting (9) into (8) yields

$$200 = 13.452V_4 \quad \longrightarrow \quad V_4 = 14.87$$

$$P = \frac{V_4^2}{20} = \underline{\underline{11.05 \text{ W}}}$$

- * 13.69 No circuito da Figura 13.132, Z_L é ajustada até a máxima potência média ser liberada para Z_L . Determine Z_L e a máxima potência média transferida para ela. Considere $N_1 = 600$ espiras e $N_2 = 200$ espiras.

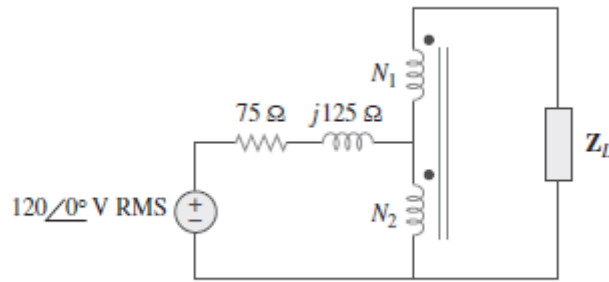
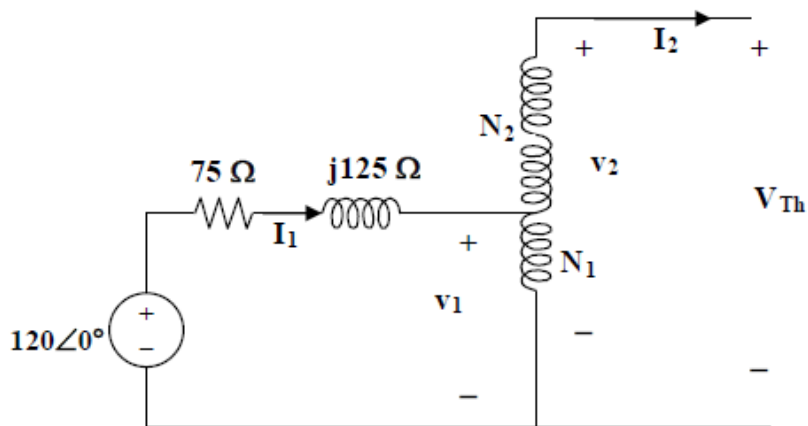


Figura 13.132 Esquema para o Problema 13.69.

We can find the Thevenin equivalent.

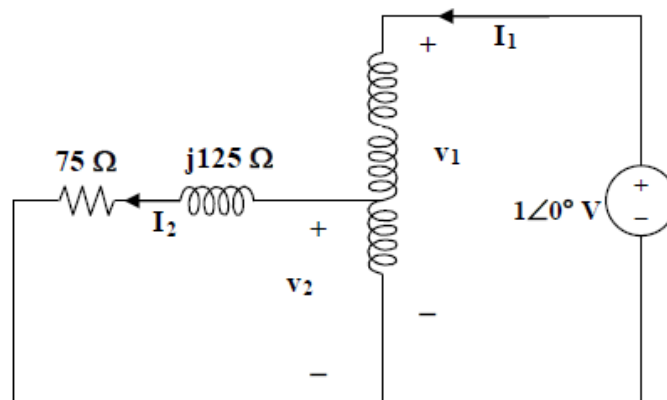


$$I_1 = I_2 = 0$$

As a step up transformer, $v_1/v_2 = N_1/(N_1 + N_2) = 600/800 = 3/4$

$$v_2 = 4v_1/3 = 4(120)/3 = 160\angle 0^\circ \text{ rms} = V_{Th}.$$

To find Z_{Th} , connect a 1-V source at the secondary terminals. We now have a step-down transformer.



$$v_1 = 1V, v_2 = I_2(75 + j125)$$

But $v_1/v_2 = (N_1 + N_2)/N_1 = 800/200$ which leads to $v_1 = 4v_2 = 1$

$$\text{and } v_2 = 0.25$$

$$I_1/I_2 = 200/800 = 1/4 \text{ which leads to } I_2 = 4I_1$$

Hence $0.25 = 4I_1(75 + j125)$ or $I_1 = 1/[16(75 + j125)]$

$$Z_{Th} = 1/I_1 = 16(75 + j125)$$

$$\text{Therefore, } Z_L = Z_{Th}^* = (1.2 - j2) \text{ k}\Omega$$

$$\text{Since } V_{Th} \text{ is rms, } p = (V_{Th}/2)^2/R_L = (80)^2/1200 = \mathbf{5.333 \text{ watts}}$$

- 13.74 Considere o transformador trifásico mostrado na Figura 13.136. O primário é alimentado por uma fonte trifásica com tensão de linha de 2,4 kV RMS, enquanto o secundário alimenta uma carga equilibrada de 120 kW com FP igual a 0,8. Determine:
- Os tipos de ligações do transformador.
 - Os valores I_{LS} e I_{PS} .
 - Os valores de I_{LP} e I_{PP} .
 - O valor nominal em kVA de cada fase do transformador.

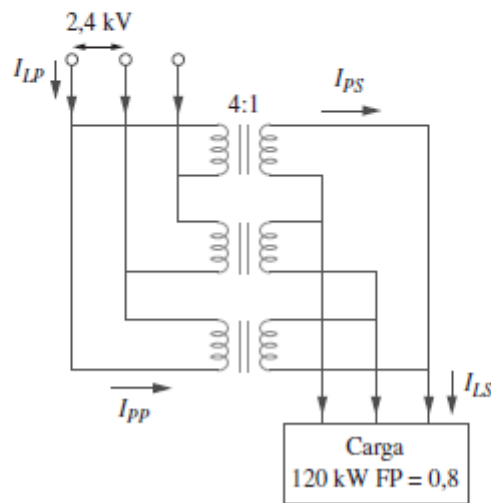


Figura 13.136 Esquema para o Problema 13.74.

- (a) This is a Δ - Δ connection.
- (b) The easy way is to consider just one phase.

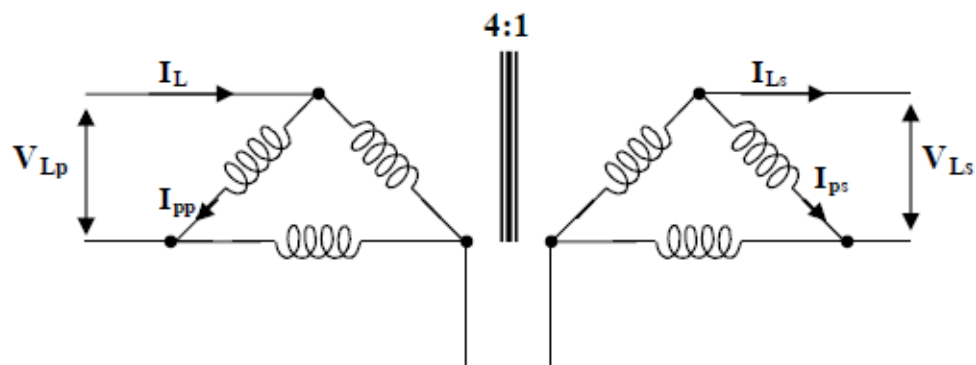
$$1:n = 4:1 \text{ or } n = 1/4$$

$$n = V_2/V_1 \text{ which leads to } V_2 = nV_1 = 0.25(2400) = 600$$

$$\text{i.e. } V_{Lp} = 2400 \text{ V and } V_{Ls} = 600 \text{ V}$$

$$S = p/\cos\theta = 120/0.8 \text{ kVA} = 150 \text{ kVA}$$

$$p_L = p/3 = 120/3 = 40 \text{ kw}$$



But $p_{Ls} = V_{ps}I_{ps}$

For the Δ -load, $I_L = \sqrt{3} I_p$ and $V_L = V_p$

Hence, $I_{ps} = 40,000/600 = 66.67 \text{ A}$

$$I_{Ls} = \sqrt{3} I_{ps} = \sqrt{3} \times 66.67 = \mathbf{115.48 \text{ A}}$$

(c) Similarly, for the primary side

$$P_{pp} = V_{pp}I_{pp} = P_{ps} \text{ or } I_{pp} = 40,000/2400 = \mathbf{16.667 \text{ A}}$$

$$\text{and } I_{Lp} = \sqrt{3} I_p = \mathbf{28.87 \text{ A}}$$

(d) Since $S = 150 \text{ kVA}$ therefore $S_p = S/3 = \mathbf{50 \text{ kVA}}$

13.77 O sistema trifásico de uma torre distribui energia elétrica **eod** com uma tensão de linha de 13,2 kV. Um transformador em um poste conectado a um único fio e ao terra abaixa a alta tensão para 120 V RMS e alimenta uma residência, conforme ilustrado na Figura 13.139.

- (a) Calcule a relação de espiras do transformador para obter 120 V.
 (b) Determine quanta corrente absorve uma lâmpada de 100 W ligada a uma linha quente de 120 V da linha de alta tensão.

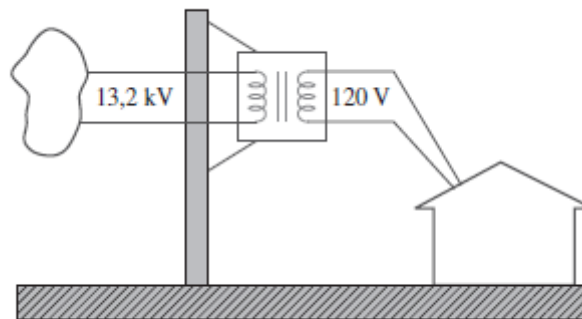


Figura 13.139 Esquema para o Problema 13.77.

- (a) This is a single phase transformer. $V_1 = 13.2 \text{ kV}$, $V_2 = 120 \text{ V}$
 $n = V_2/V_1 = 120/13,200 = 1/110$, therefore $n = \mathbf{1/110}$
 or 110 turns on the primary to every turn on the secondary.
- (b) $P = VI$ or $I = P/V = 100/120 = 0.8333 \text{ A}$
 $I_1 = nI_2 = 0.8333/110 = \mathbf{7.576 \text{ mA}}$