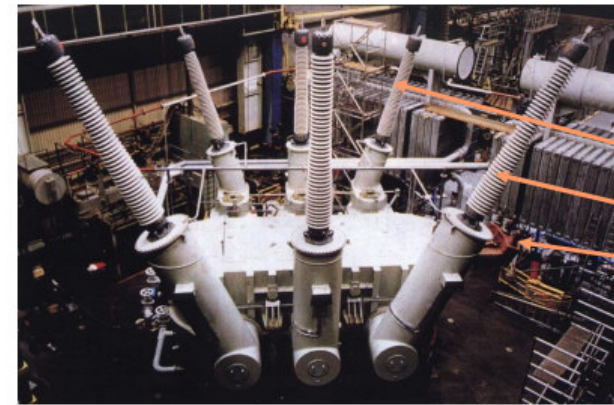




Sistemas Elétricos de Potência

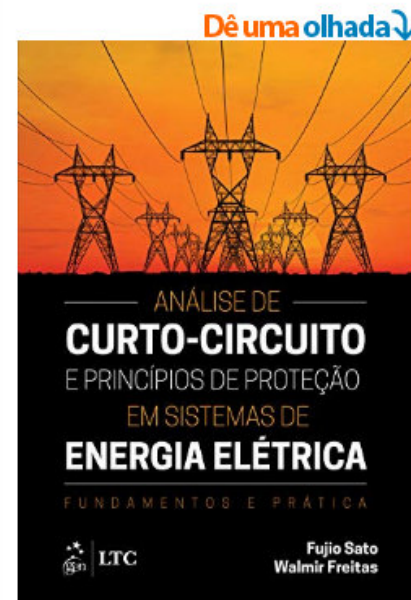
Aula 08-P1 – Autotransformador: Conceitos Iniciais e Cálculo de Curto-circuito Trifásico

Prof. Heverton Augusto Pereira
heverton.pereira@ufv.br

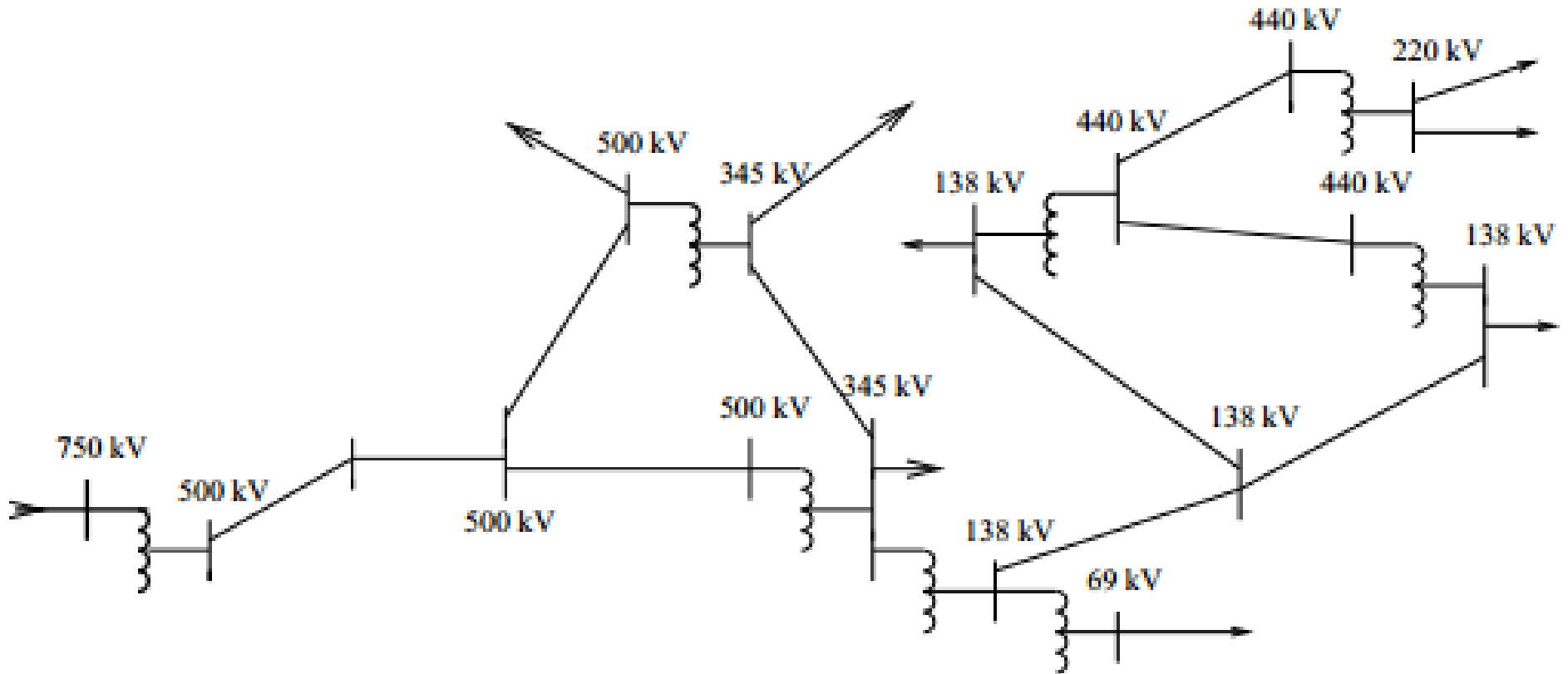


Tópicos abordados

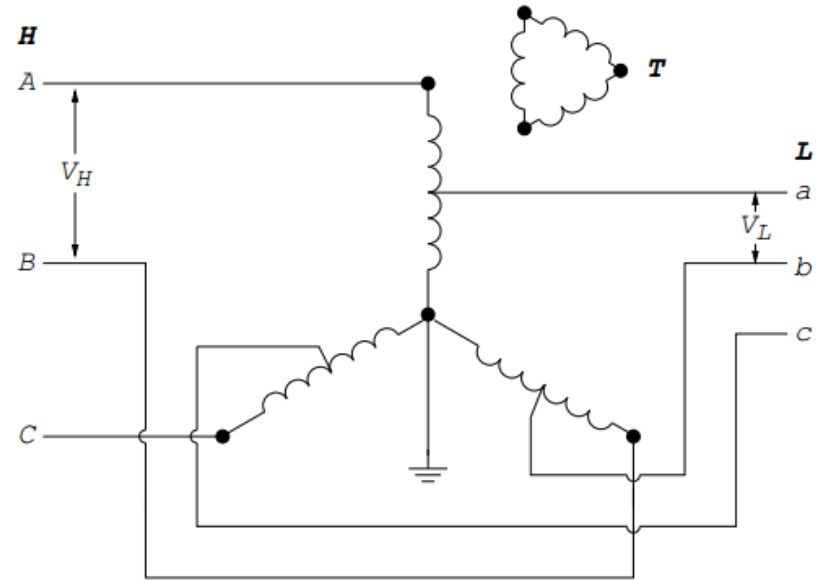
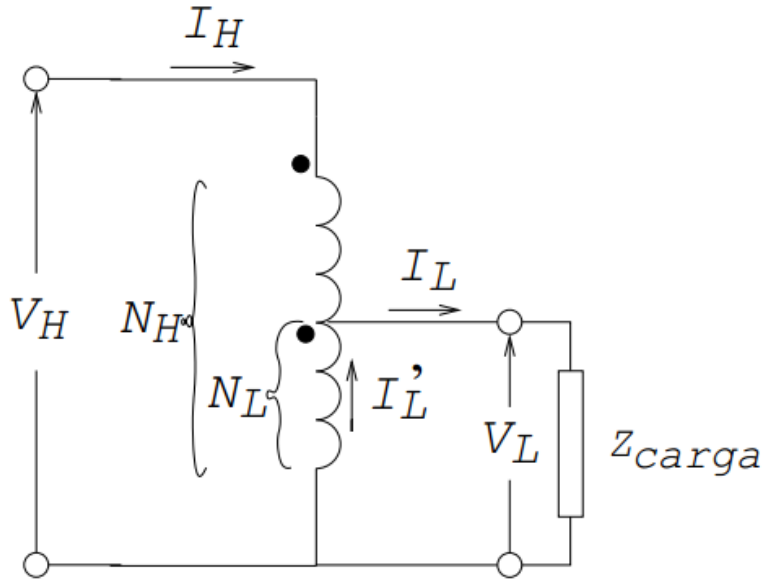
- Capítulo 1
- Capítulo 4
- Capítulo 6



Autotransformador



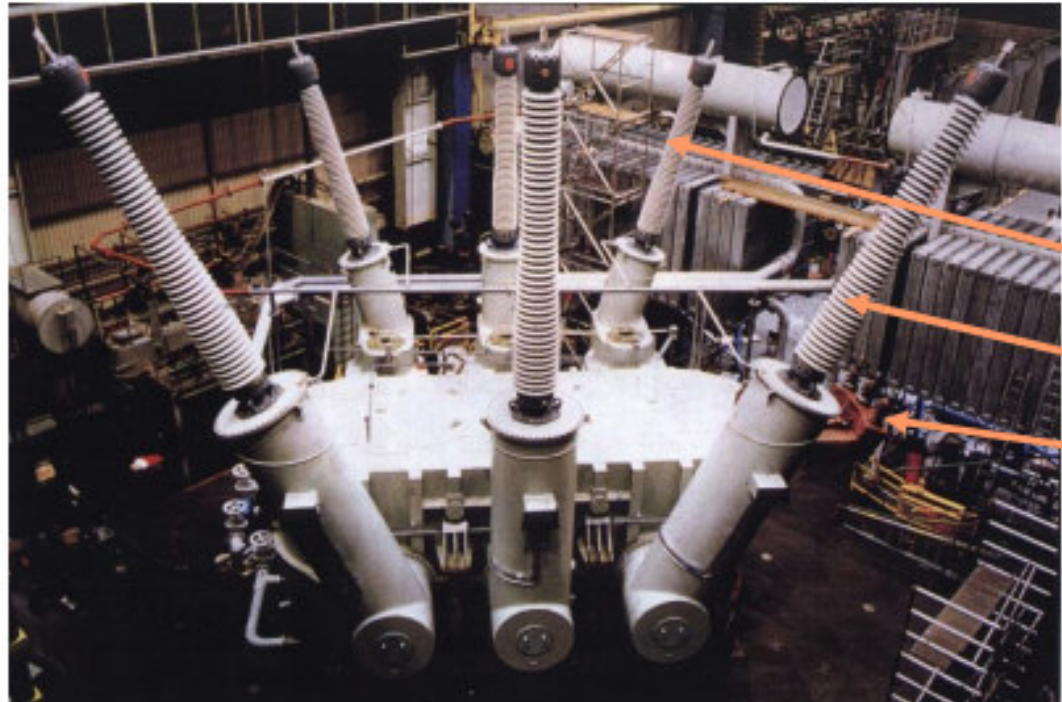
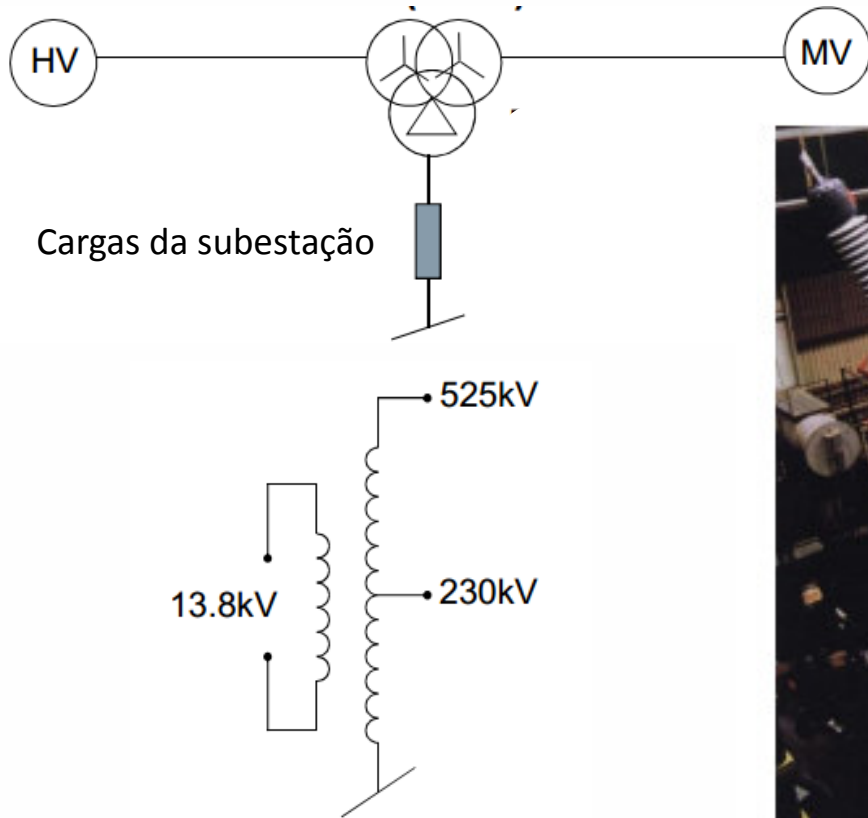
Autotransformador Monofásico e Trifásico



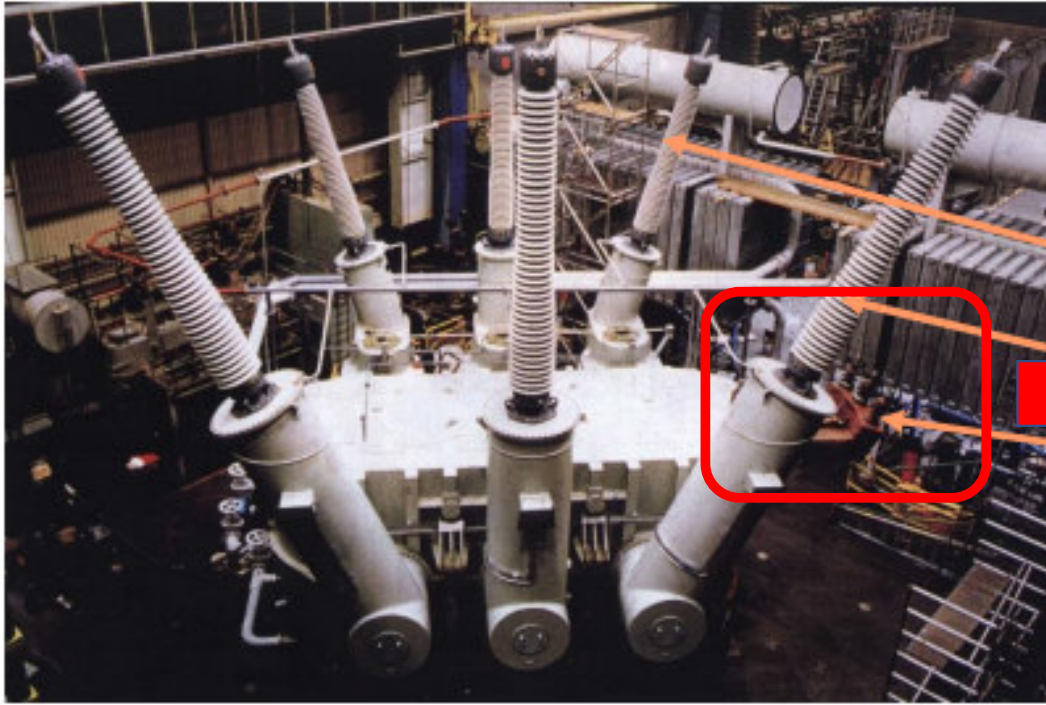
Autotransformador de Distribuição e de Partida de Motores



Autotransformador de Potência



Autotransformador de Potência



Autotransformador

<i>Descrição</i>	<i>Transf.</i>	<i>Autotransf.</i>
V_H	500 kV	500 kV
V_L	275 kV	275 kV
S_T	600 MVA	600 MVA
S_{transf}	600 MVA	270 MVA
α	1,0	0,45
Peso da parte ativa	1,0	0,67
Quantidade de óleo	1,0	0,89
Peso total	1,0	0,72
Perda no ferro	1,0	0,71
Perda no cobre	1,0	0,68
Perda total	1,0	0,69

Vantagens do Autotransformador

- Alto rendimento
- Baixa impedância
- Tamanho menor
- Menor custo

Características do Autotransformador

- Enrolamento terciário é dimensionada entre 20% e 35% da capacidade do enrolamento principal
- Deve suportar térmica e mecanicamente a corrente de sequência zero durante um curto-circuito monofásico, tanto no lado de alta quanto no lado de baixa do autotransformador

Impedâncias do Autotransformador

<i>Ensaio</i>	<i>Tensão</i>	<i>Curto-circuito</i>	<i>Aberto</i>	<i>Impedância %</i>
1	alta	baixa	terciária	$z_{HL_n} \%$
2	alta	terciária	baixa	$z_{HT_n} \%$
3	baixa	terciária	alta	$z_{LT_n} \%$

Estas impedâncias são determinadas baseando-se nas potências nominais de cada enrolamento.

Autotransformador

$$z_{HL}\% = z_{HL_n}\% \frac{S_{base}}{S_{HL_n}}$$

$$z_{HL}\% = z_H\% + z_L\%$$

$$z_H\% = \frac{z_{HL}\% + z_{HT}\% - z_{LT}\%}{2}$$

$$z_{HT}\% = z_{HT_n}\% \frac{S_{base}}{S_{HT_n}}$$

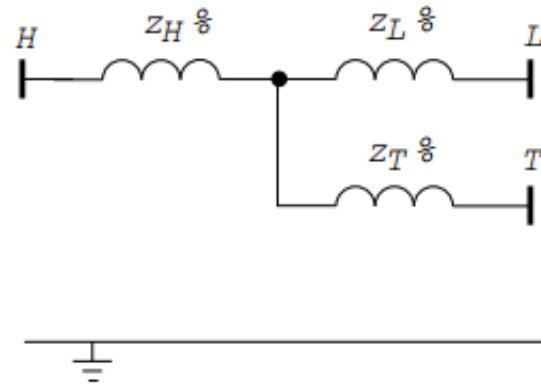
$$z_{HT}\% = z_H\% + z_T\%$$

$$z_L\% = \frac{z_{HL}\% - z_{HT}\% + z_{LT}\%}{2}$$

$$z_{LT}\% = z_{LT_n}\% \frac{S_{base}}{S_{LT_n}}$$

$$z_{LT}\% = z_L\% + z_T\%$$

$$z_T\% = \frac{-z_{HL}\% + z_{HT}\% + z_{LT}\%}{2}$$



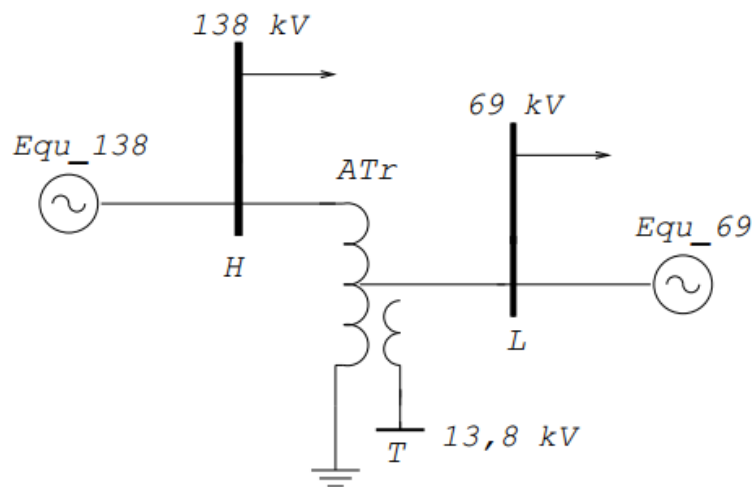
Autotransformador

$$S_{base} = 100 \text{ MVA}$$

$$V_{base} = 138 \text{ kV}$$

$$z_{eq138}^+ = j8\%$$

$$z_{eq138}^0 = j16\%$$



$$S_{base} = 100 \text{ MVA}$$

$$V_{base} = 69 \text{ kV}$$

$$z_{eq69}^+ = j40\%$$

$$z_{eq69}^0 = j80\%$$

$$z_{HL}^+ = z_{HL}^0 = j6,07\% (S_{base} = 25 \text{ MVA})$$

$$z_{HT}^+ = z_{HT}^0 = j5,99\% (S_{base} = 8,75 \text{ MVA})$$

$$z_{LT}^+ = z_{LT}^0 = j3,7\% (S_{base} = 8,75 \text{ MVA})$$

Autotransformador

$$z_{HL}\% = j6,07\% \frac{100,0}{25,0} = j24,28\%$$

$$z_H\% = \frac{z_{HL}\% + z_{HT}\% - z_{LT}\%}{2}$$

$$z_{HT}\% = j5,99\% \frac{100,0}{8,75} = j68,46\%$$

$$z_L\% = \frac{z_{HL}\% - z_{HT}\% + z_{LT}\%}{2}$$

$$z_{LT}\% = j3,70\% \frac{100,0}{8,75} = j42,29\%$$

$$z_T\% = \frac{-z_{HL}\% + z_{HT}\% + z_{LT}\%}{2}$$

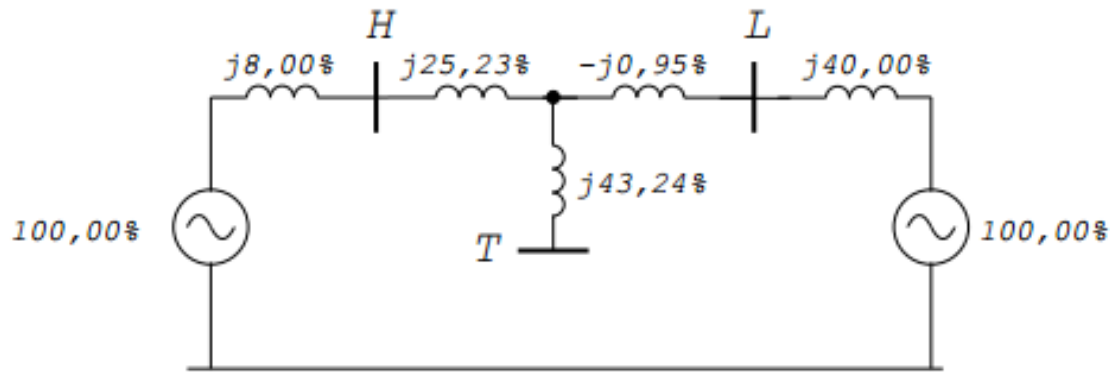
$$z_H\% = \frac{j24,28\% + j68,46\% - j42,29\%}{2} = j25,23\%$$

$$z_L\% = \frac{j24,28\% - j68,46\% + j42,29\%}{2} = -j0,95\%$$

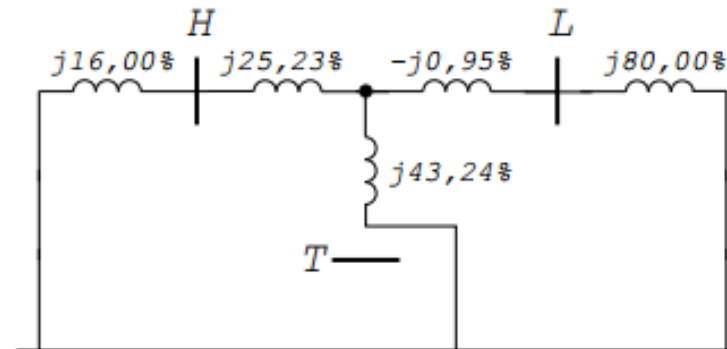
$$z_T\% = \frac{-j24,28\% + j68,46\% + j42,29\%}{2} = j43,24\%$$

Diagramas de Sequência

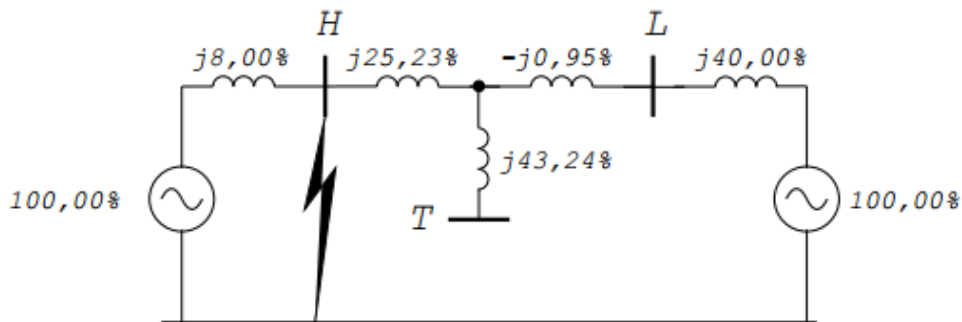
Sequência positiva:



Sequência zero:



Curto-circuito Trifásico em H



$$I_{base} = \frac{100 \times 10^6}{\sqrt{3} \times 138 \times 10^3} = 418,37 \text{ A}$$

$$I_{cch}^{3\phi} = -j14,055 \times 418,37$$

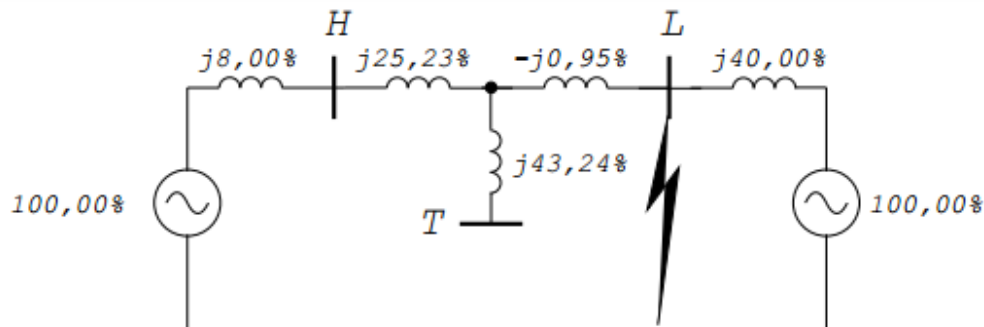
$$I_{cch}^{3\phi} = -j5.880,2 \text{ A}$$

$$z_{\%}^{+}(eq_H) = \frac{j8,0\% \times (j25,23\% - j0,95\% + j40,0\%)}{j8,0\% + j25,23\% - j0,95\% + j40,0\%}$$

$$z_{\%}^{+}(eq_H) = j7,1145\%$$

$$i_{cch}^{3f} = \frac{100,0}{j7,1145} = -j14,055 \text{ pu}$$

Curto-circuito Trifásico em L



$$I_{base} = \frac{100 \times 10^6}{\sqrt{3} \times 69 \times 10^3} = 836,74 \text{ A}$$

$$I_{cCL}^{3\phi} = -j5,598 \times 836,74$$

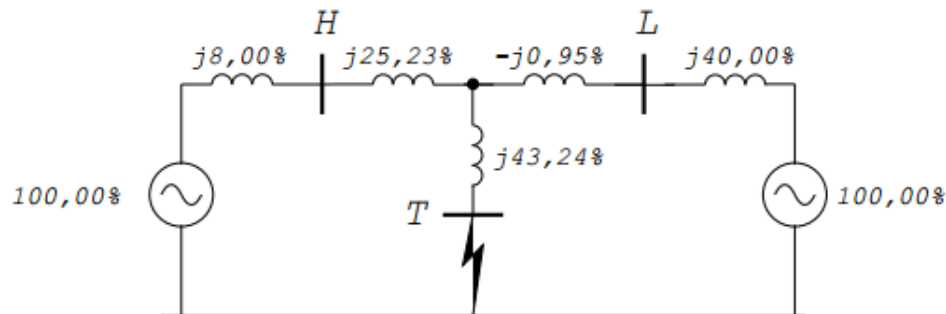
$$I_{cCL}^{3\phi} = -j4.684 \text{ A}$$

$$z_{\%}^{+}(eq_L) = \frac{j40,0\% \times (j25,23\% - j0,95\% + j80,0\%)}{j40,0\% + j25,23\% - j0,95\% + j8,0\%}$$

$$z_{\%}^{+}(eq_L) = j17,8639\%$$

$$i_{cCL}^{3f} = \frac{100,0}{j17,8639} = -j5,598 \text{ pu}$$

Curto-circuito Trifásico em T



$$z_{\%}^{+}(eq_T) = \frac{(j33,23\% \times j39,05\%)}{(j33,23\% + j39,05\%)} + j43,24\%$$

$$z_{\%}^{+}(eq_T) = j61,1928$$

$$i_{ccT}^{3f} = \frac{100,0}{j61,1928} = -j1,6341 \text{ pu}$$

$$I_{base} = \frac{100 \times 10^6}{\sqrt{3} \times 13,8 \times 10^3} = 4183,7 \text{ A}$$

$$I_{ccT}^{3\phi} = -j1,6341 \times 4183,7$$

$$I_{ccT}^{3\phi} = -j6.836,9 \text{ A}$$



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Obrigado!

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