石家莊鐵道大學
SHIJIAZHUANG TIEDAO UNIVERSITY

在线开放课程

电力系统简单不对称故障的分析计算

简单不对称短路的实例讲解

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9.4 简单不对称短路的实例讲解

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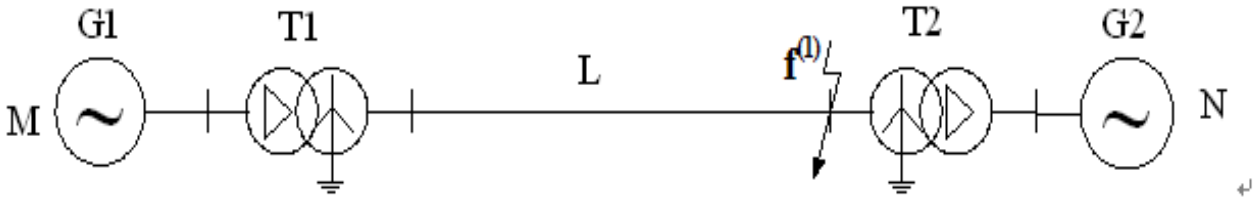
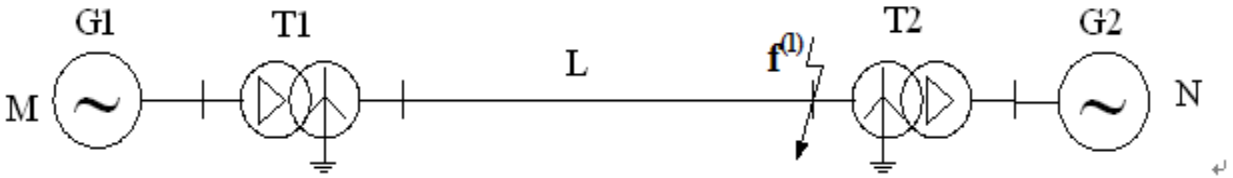
例 1、电力网络接线如图 4 所示。当在 f 点发生 a 相短路时，求短路起始瞬间故障处的各序电气量及其各相量。



9.4 简单不对称短路的实例讲解



各元件参数：

G1： 62.5MVA, 10.5kV, $x''_{d}=0.125$, $x_2=0.16$, $E''_{M}=11\text{kV}$

G2： 31.5MVA, 10.5kV, $x''_{d}=0.125$, $x_2=0.16$, $E''_{N}=10.5\text{kV}$

T1： 60MVA, 10.5kV/121kV, $U_k\%=10.5$

T2：31.5MVA, 10.5kV/121kV, $U_k\%=10.5$$L$：

$x_1=x_2=0.4\Omega/\text{km}$, $x_0=2x_1$, $L=40\text{km}$

9.4 简单不对称短路的实例讲解

(1)计算各序网络的等值参数。

选取 $S_B = 100\text{MVA}$，选取各段的平均电压，计算各元件参数的电抗标幺值，并画出各序网等值电路图：

9.4 简单不对称短路的实例讲解

正序网络的等值参数为：

$$X_{G1(1)} = x''_d \times \frac{S_B}{S_{G1(N)}} = 0.125 \times \frac{100}{62.5} = 0.2$$

$$X_{T1(1)} = \frac{U_k\%}{100} \times \frac{S_B}{S_{T1(N)}} = \frac{10.5}{100} \times \frac{100}{60} = 0.175$$

$$X_{L(1)} = x_1 \times L \times \frac{S_B}{U_B^2} = 0.4 \times 40 \times \frac{100}{115^2} = 0.121$$

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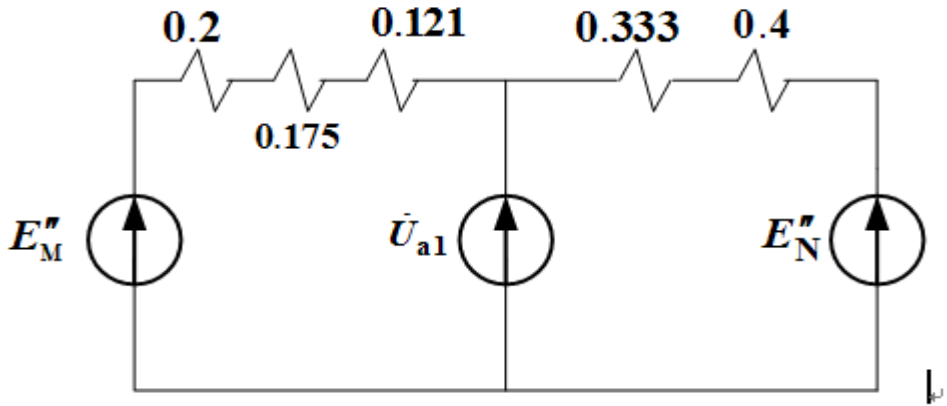
$$X_{G2(1)} = x''_d \times \frac{S_B}{S_{G2(N)}} = 0.125 \times \frac{100}{31.5} = 0.4$$

$$X_{T2(1)} = \frac{U_k\%}{100} \times \frac{S_B}{S_{T2(N)}} = \frac{10.5}{100} \times \frac{100}{31.5} = 0.333$$

正序网络：



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负序网络的等值参数为：

$$X_{G1(2)} = x_2 \times \frac{S_B}{S_{G1(N)}} = 0.16 \times \frac{100}{62.5} = 0.256$$

$$X_{T1(2)} = X_{T1(1)} = 0.175$$

$$X_{L(1)} = X_{L(2)} = 0.121$$

$$X_{G2(1)} = x_2 \times \frac{S_B}{S_{G2(N)}} = 0.16 \times \frac{100}{31.5} = 0.512$$

$$X_{T2(2)} = X_{T2(1)} = 0.333$$

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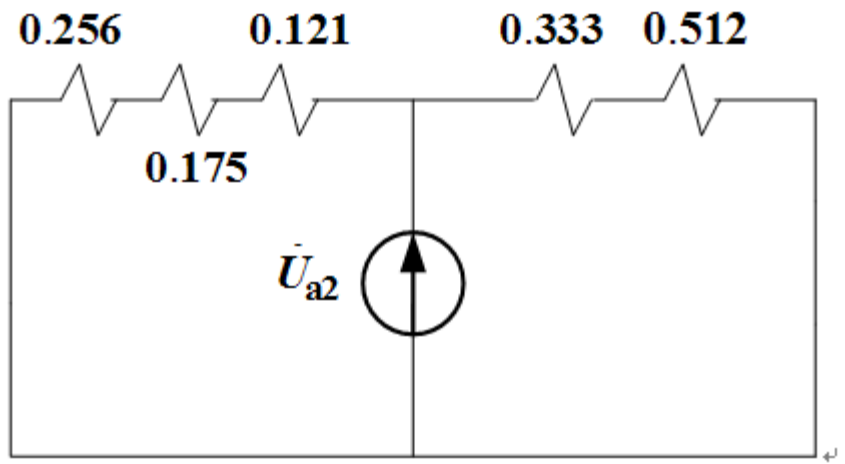
负序网络



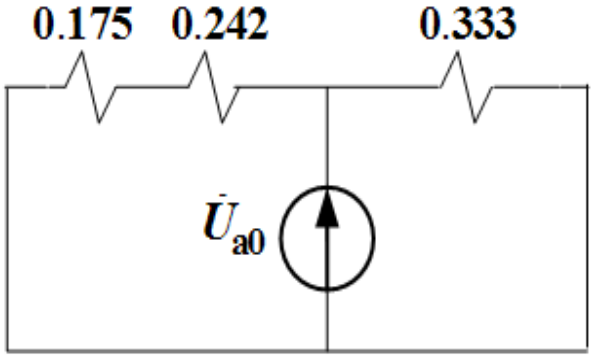
9.4 简单不对称短路的实例讲解

零序网络的等值参数为：

$$X_{T1(0)} = X_{T1(1)} = 0.175 \qquad X_{T2(0)} = X_{T2(1)} = 0.333$$

$$X_{L(0)} = 2X_{L(0)} = 2 \times 0.121 = 0.242$$

零序网络

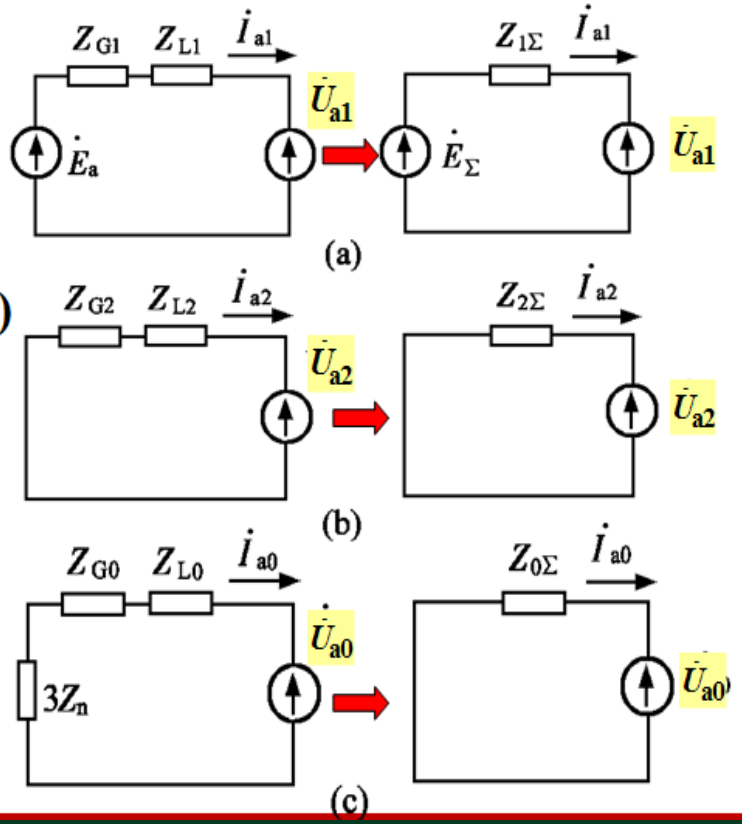


9.4 简单不对称短路的实例讲解

☞ 序网方程

$$\begin{cases} \dot{U}_{a1}=\dot{E}_a-\dot{I}_{a1}(Z_{G1}+Z_{L1}) \\ \dot{U}_{a2}=0-\dot{I}_{a2}(Z_{G2}+Z_{L2}) \\ \dot{U}_{a0}=0-\dot{I}_{a0}(Z_{G0}+Z_{L0}+3Z_n) \end{cases}$$

$$\begin{cases} \dot{E}_\Sigma-\dot{I}_{a1}Z_{1\Sigma}=\dot{U}_{a1} \\ 0-\dot{I}_{a2}Z_{2\Sigma}=\dot{U}_{a2} \\ 0-\dot{I}_{a0}Z_{0\Sigma}=\dot{U}_{a0} \end{cases}$$



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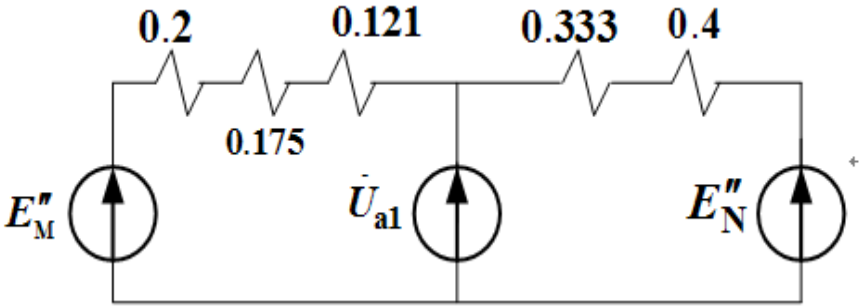
正序网络：



各序网路的等值参数为：

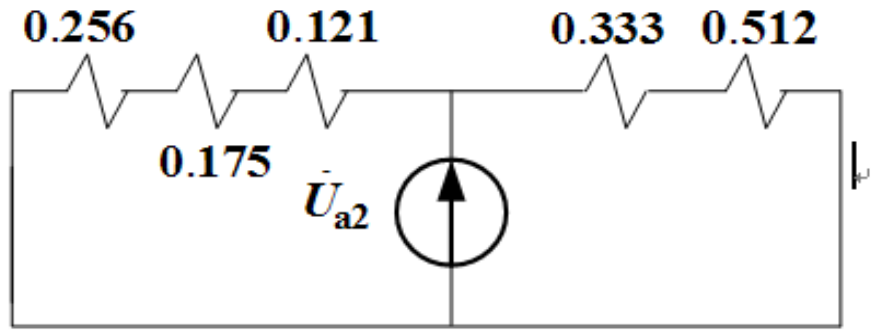
$$X_{1\Sigma}=\frac{(0.2+0.175+0.121)\times(0.333+0.4)}{0.2+0.175+0.121+0.333+0.4}=0.296$$

$$E''_{\Sigma}=\frac{E''_M(0.333+0.4)+E''_N(0.2+0.175+0.121)}{0.2+0.175+0.121+0.333+0.4}$$

$$=\frac{1.05\times0.733+1\times0.496}{0.496+0.733}=1.03$$

9.4 简单不对称短路的实例讲解

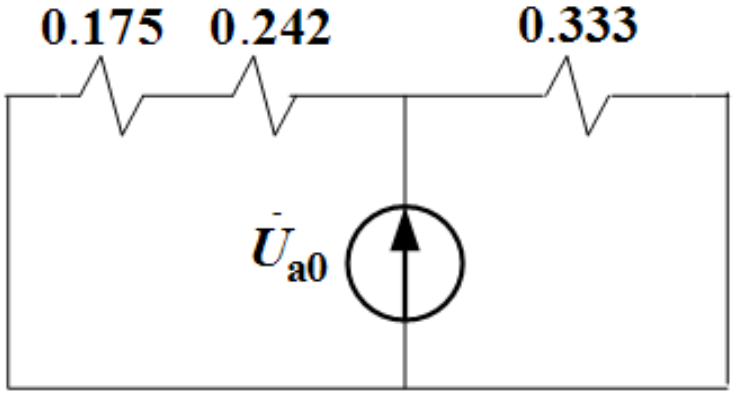
负序网络



$$X_{2\Sigma}=\frac{(0.256+0.175+0.121)\times(0.333+0.512)}{0.256+0.175+0.121+0.333+0.512}=0.334$$

9.4 简单不对称短路的实例讲解

零序网络

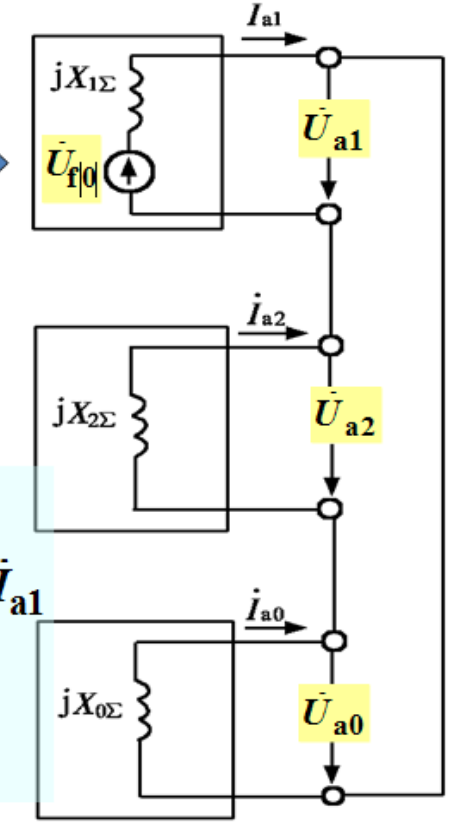


$$X_{0\Sigma}=\frac{(0.175+0.242)\times 0.333}{0.175+0.242+0.333}=0.185$$

9.4 简单不对称短路的实例讲解

1、单相接地故障的复合序网

$$\begin{cases}\dot{U}_{a1}+\dot{U}_{a2}+\dot{U}_{a0}=0\\ \dot{I}_{a1}=\dot{I}_{a2}=\dot{I}_{a0}\end{cases}$$



$$\dot{I}_{a1}=\frac{\dot{U}_{f|0|}}{j(X_{1\Sigma}+X_{2\Sigma}+X_{0\Sigma})}$$

$$\begin{cases}\dot{I}_{a2}=\dot{I}_{a0}=\dot{I}_{a1}\\ \dot{U}_{a1}=\dot{U}_{f|0|}-jX_{1\Sigma}\dot{I}_{a1}=j(X_{2\Sigma}+X_{0\Sigma})\dot{I}_{a1}\\ \dot{U}_{a2}=-jX_{2\Sigma}\dot{I}_{a2}\\ \dot{U}_{a0}=-jX_{0\Sigma}\dot{I}_{a0}\end{cases}$$

9.4 简单不对称短路的实例讲解

(2) 计算各序电气量及各相量

$$\dot{I}_{fa(1)} = \dot{I}_{fa(2)} = \dot{I}_{fa(0)} = \frac{\dot{E}''_{\Sigma}}{j(X_{1\Sigma} + X_{2\Sigma} + X_{0\Sigma})}$$

$$= \frac{1.03}{j(0.296 + 0.334 + 0.185)} = -j1.264$$

$$\dot{U}_{fa(1)} = \dot{E}''_{\Sigma} - j\dot{I}_{fa(1)}X_{1\Sigma}$$

$$= 1.03 - j(-j1.264) \times 0.296 = 0.656$$

$$\dot{U}_{fa(2)} = -j\dot{I}_{fa(2)}X_{2\Sigma} = -j(-j1.264) \times 0.334 = -0.422$$

$$\dot{U}_{fa(0)} = -j\dot{I}_{fa(0)}X_{0\Sigma} = -j(-j1.264) \times 0.185 = -0.234$$

9.4 简单不对称短路的实例讲解

故障处各相电流、电压

$$\dot{I}_{fa} = 3\dot{I}_{fa(1)} = 3\times(-j1.264) = -j3.792$$

$$\dot{I}_{fb} = \dot{I}_{fc} = 0$$

$$\dot{U}_{fa} = \dot{U}_{fa(1)} + \dot{U}_{fa(2)} + \dot{U}_{fa(0)} = 0$$

$$\dot{U}_{fb} = a^2\dot{U}_{fa(1)} + a\dot{U}_{fa(2)} + \dot{U}_{fa(0)} = 0.656a^2 - 0.424a - 0.234$$

$$= -0.351 - j0.933 = 0.977e^{-j110.6^\circ}$$

$$\dot{U}_{fc} = a\dot{U}_{fa(1)} + a^2\dot{U}_{fa(2)} + \dot{U}_{fa(0)} = 0.656a - 0.424a^2 - 0.234$$

$$= -0.351 + j0.933 = 0.977e^{j110.6^\circ}$$

9.4 简单不对称短路的实例讲解

故障处各相电流、电压的有名值

$$I_B = \frac{100}{\sqrt{3} \times 115} = 0.502(\text{kA}) \qquad U_B = \frac{115}{\sqrt{3}} = 66.4(\text{kV})$$

$$\left|\dot{I}_{fa}\right| = 3.792 \times 0.502 = 1.904(\text{kA})$$

$$\left|\dot{U}_{fb}\right| = \left|\dot{U}_{fc}\right| = 0.977 \times 66.4 = 66.2(\text{kV})$$

小结

- 用实例讲解了单相接地短路的计算方法；