第八章 电力系统不对称故障的分析和计算

8-1 简单不对称短路的分析

8-2 电压和电流对称分量经变压器后的相位变换

8-3 非全相断线的分析

8-4 应用节点阻抗矩阵计算不对称故障

武器1. 对称分量法

$$\begin{bmatrix} \dot{I}_a \\ \dot{I}_b \\ \dot{I}_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix}$$

$$\begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} \dot{I}_a \\ \dot{I}_b \\ \dot{I}_c \end{bmatrix}$$

武器1. 对称分量法

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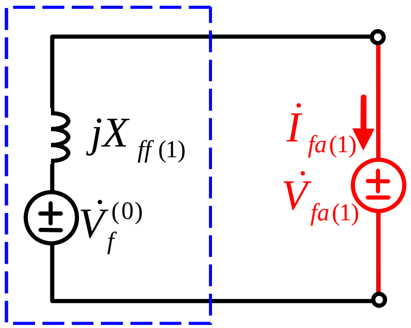
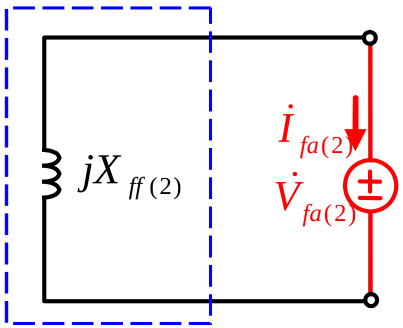
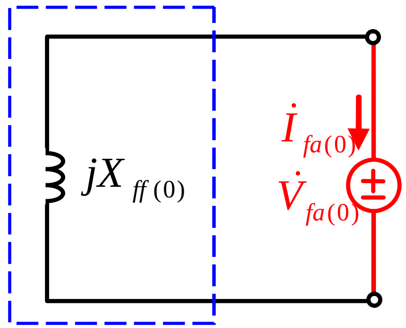
$$\begin{bmatrix}\dot I_{a(1)}\\ \dot I_{a(2)}\\ \dot I_{a(0)}\end{bmatrix}=\frac{1}{3}\begin{bmatrix}1 & \alpha & \alpha^2\\ 1 & \alpha^2 & \alpha\\ 1 & 1 & 1\end{bmatrix}\begin{bmatrix}\dot I_a\\ \dot I_b\\ \dot I_c\end{bmatrix}$$

武器2：序网电路与方程（外加3个边界条件方程）







$$\dot V_{fa(1)}=\dot V_f^{(0)}-jX_{ff(1)}\dot I_{fa(1)}$$

$$\dot V_{fa(2)}=-jX_{ff(2)}\dot I_{fa(2)}$$

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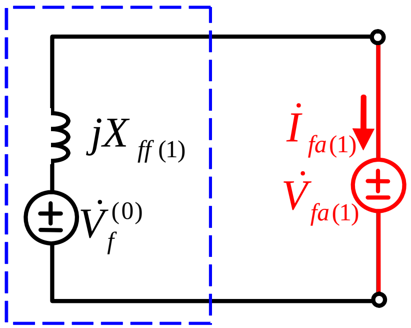
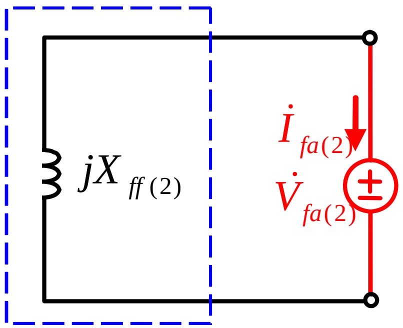
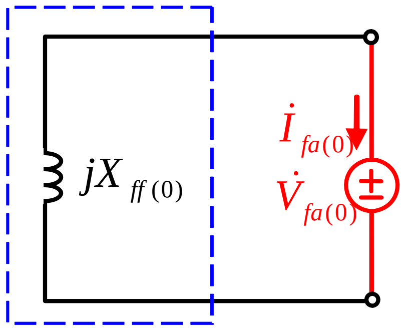
武器2：序网电路与方程（外加3个边界条件方程）







$$\dot{V}_{fa(1)} = \dot{V}_f^{(0)} - jX_{ff(1)}\dot{I}_{fa(1)}$$

$$\dot{V}_{fa(2)} = -jX_{ff(2)}\dot{I}_{fa(2)}$$

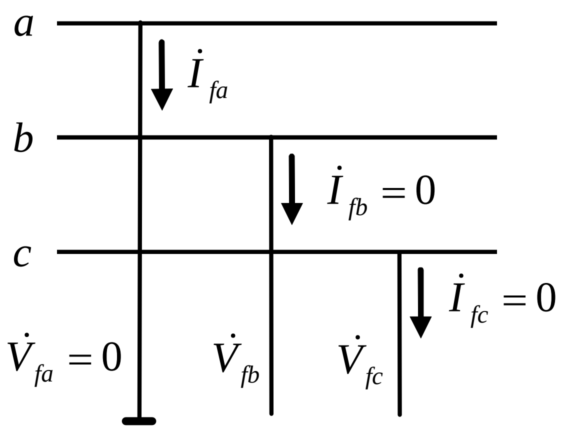
$$\dot{V}_{fa(0)} = -jX_{ff(0)}\dot{I}_{fa(0)}$$

武器3：故障特殊相/参考相的选取

8-1 简单不对称短路的分析

1. 单相(a相)接地短路——序分量边界条件

(1)相量表示的边界条件：$\dot{V}_{fa}=0,\ \dot{I}_{fb}=0,\ \dot{I}_{fc}=0$



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(2) 对称分量表示的边界条件

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

$$\dot{I}_{fb}=\dot{I}_{fb(1)}+\dot{I}_{fb(2)}+\dot{I}_{fb(0)}=0$$

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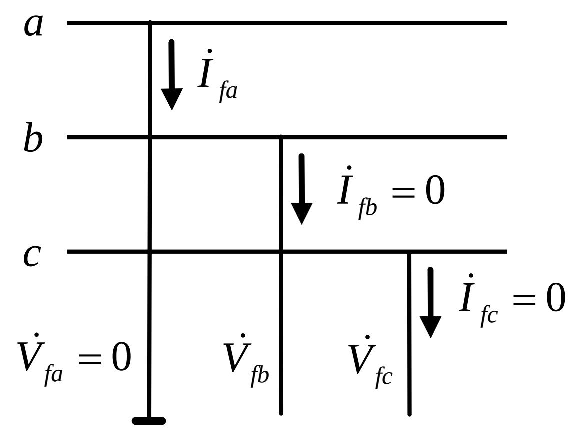

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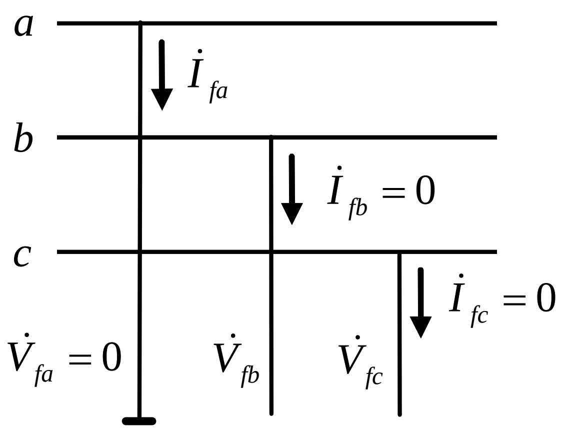
$$\dot{I}_{fc}=\dot{I}_{fc(1)}+\dot{I}_{fc(2)}+\dot{I}_{fc(0)}=0$$

(3) 以a相为参考相

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

$$\dot{I}_{fb}=\alpha^2\dot{I}_{fa(1)}+\alpha\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$

$$\dot{I}_{fc}=\alpha\dot{I}_{fa(1)}+\alpha^2\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$



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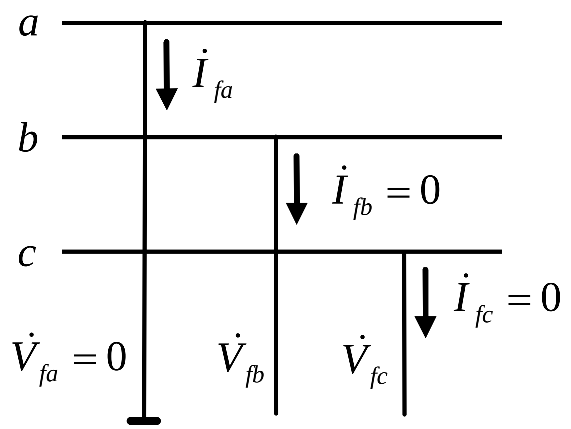

(2) 对称分量表示的边界条件

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$$\dot{I}_{fc}=\dot{I}_{fc(1)}+\dot{I}_{fc(2)}+\dot{I}_{fc(0)}=0$$

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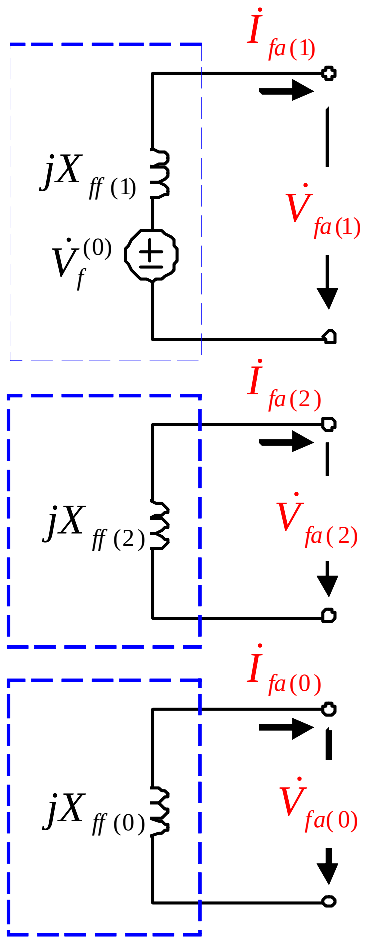
$$\dot{V}_{fa}=\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0$$
$$\dot{I}_{fb}=\alpha^2\dot{I}_{fa(1)}+\alpha\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$
$$\dot{I}_{fc}=\alpha\dot{I}_{fa(1)}+\alpha^2\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$

(4) 序分量边界条件：

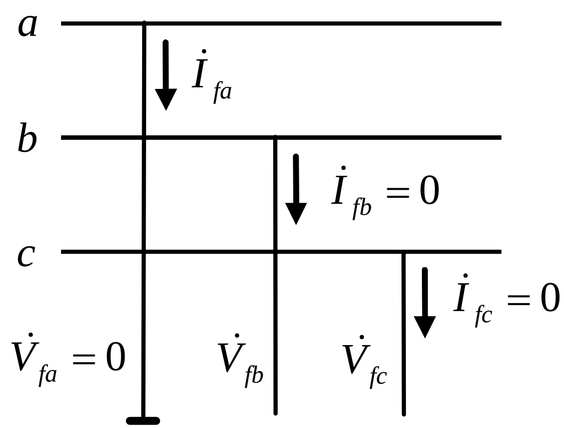
$$\left.\begin{aligned}&\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0\\&\dot{I}_{fa(1)}=\dot{I}_{fa(2)}=\dot{I}_{fa(0)}\end{aligned}\right\}(8\text{-}2)$$

8-1 简单不对称短路的分析

1. 单相(a相)接地短路——复合序网



$$\boxed{\left.\begin{aligned} &\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0 \\ &\dot{I}_{fa(1)}=\dot{I}_{fa(2)}=\dot{I}_{fa(0)} \end{aligned}\right\}(8-2)}$$



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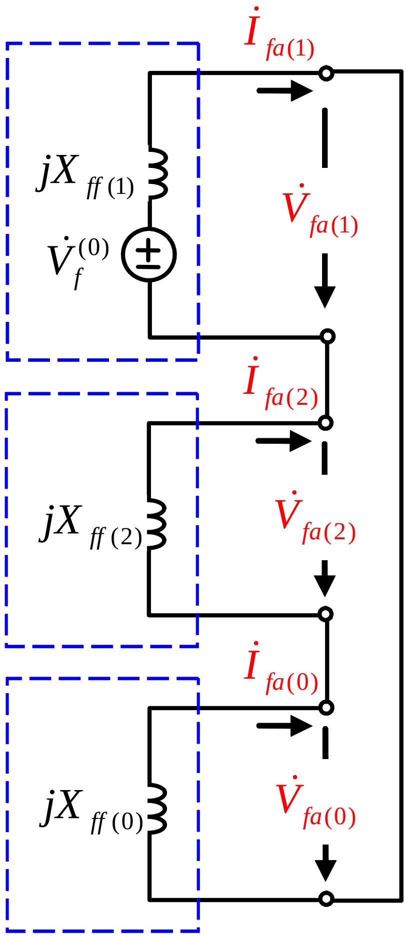
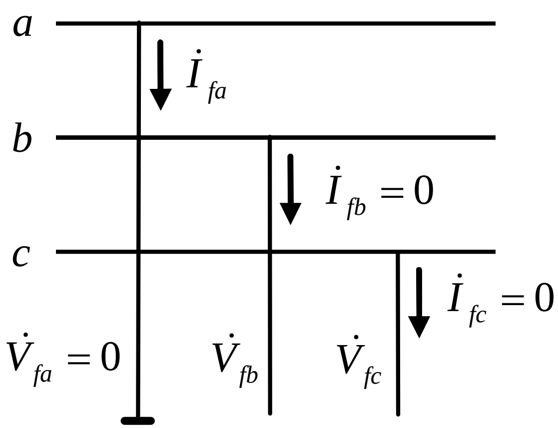


$$\boxed{\left.\begin{array}{l}\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0\\ \dot{I}_{fa(1)}=\dot{I}_{fa(2)}=\dot{I}_{fa(0)}\end{array}\right\}(8-2)}$$



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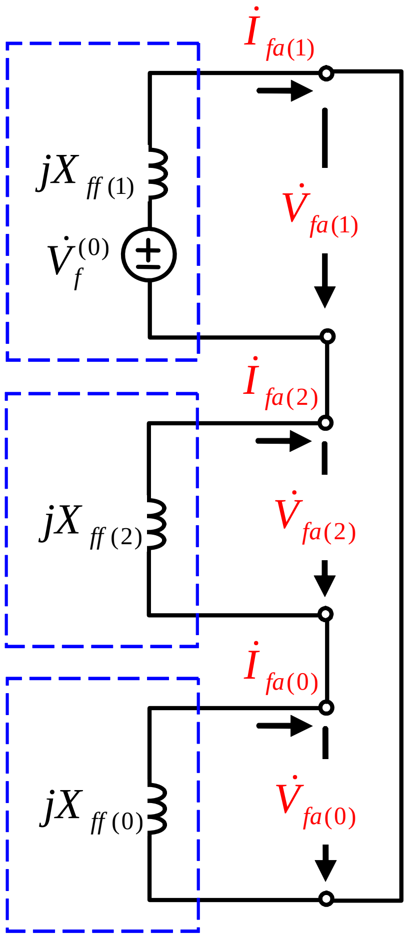
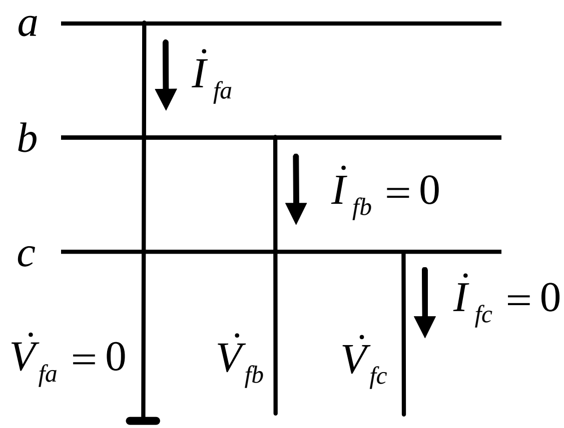


$$\left.\begin{aligned}&\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0\\&\dot{I}_{fa(1)}=\dot{I}_{fa(2)}=\dot{I}_{fa(0)}\end{aligned}\right\}(8-2)$$

$$\left.\begin{aligned}\dot{V}_{fa(1)}&=\dot{V}_f^{(0)}-jX_{ff(1)}\dot{I}_{fa(1)}\\&=j\left(X_{ff(2)}+X_{ff(0)}\right)\dot{I}_{fa(1)}\\\dot{V}_{fa(2)}&=-jX_{ff(2)}\dot{I}_{fa(2)}\\\dot{V}_{fa(0)}&=-jX_{ff(0)}\dot{I}_{fa(0)}\end{aligned}\right\}$$



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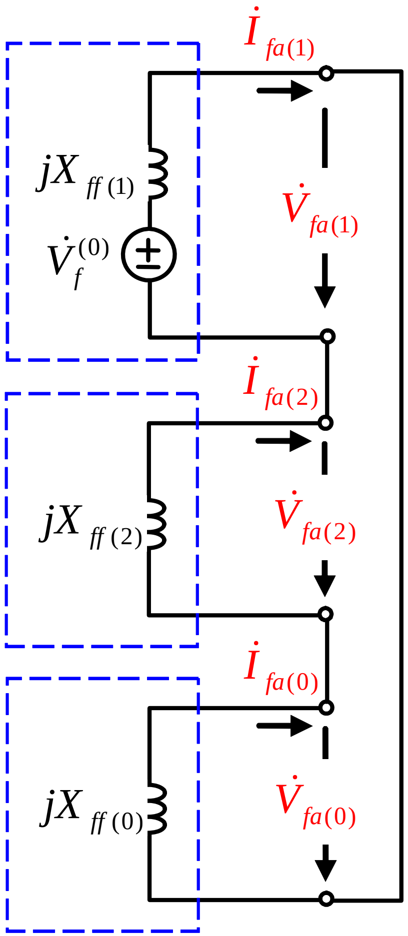
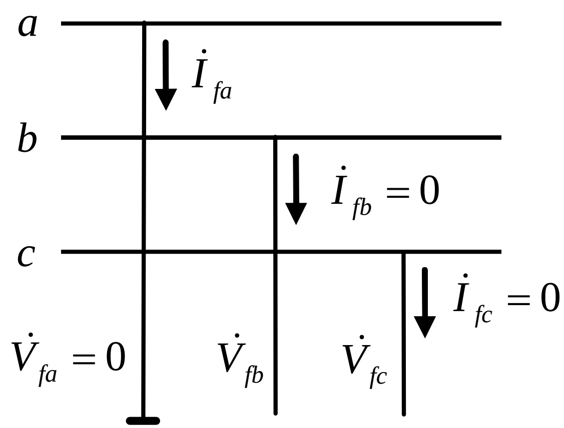


$$\left.\begin{aligned} &\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0 \\ &\dot{I}_{fa(1)}=\dot{I}_{fa(2)}=\dot{I}_{fa(0)} \end{aligned}\right\}(8-2)$$

$$\left.\begin{aligned} \dot{V}_{fa(1)} &= \dot{V}_f^{(0)} - jX_{ff(1)}\dot{I}_{fa(1)} \\ &= j\left(X_{ff(2)}+X_{ff(0)}\right)\dot{I}_{fa(1)} \\ \dot{V}_{fa(2)} &= -jX_{ff(2)}\dot{I}_{fa(2)} \\ \dot{V}_{fa(0)} &= -jX_{ff(0)}\dot{I}_{fa(0)} \end{aligned}\right\}$$



$$\dot{I}_{fa(1)}=\frac{\dot{V}_f^{(0)}}{j(X_{ff(1)}+X_{ff(2)}+X_{ff(0)})} \quad (8-3)$$

8-1 简单不对称短路的分析

1. 单相(a相)接地短路——故障点各相电流电压

$$\dot{I}_f^{(1)} = \dot{I}_{fa} = \frac{3\dot{V}_f^{(0)}}{j(X_{ff(1)} + X_{ff(2)} + X_{ff(0)})}$$

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

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1. 单相(a相)接地短路——故障点各相电流电压

$$\dot I_f^{(1)} = \dot I_{fa} = \frac{3\dot V_f^{(0)}}{j(X_{ff(1)} + X_{ff(2)} + X_{ff(0)})}$$

$$\dot I_{fb} = 0, \qquad \dot I_{fc} = 0$$

$$\dot V_{fa} = 0$$

$$\dot V_{fb} = \alpha^2 \dot V_{fa(1)} + \alpha \dot V_{fa(2)} + \dot V_{fa(0)} = j\left[(\alpha^2 - \alpha) X_{ff(2)} + (\alpha^2 - 1) X_{ff(0)}\right] \dot I_{fa(1)}$$

$$\dot V_{fc} = \alpha \dot V_{fa(1)} + \alpha^2 \dot V_{fa(2)} + \dot V_{fa(0)} = j\left[(\alpha - \alpha^2) X_{ff(2)} + (\alpha - 1) X_{ff(0)}\right] \dot I_{fa(1)}$$

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

$$\dot{V}_{fa} = 0$$

$$\dot{V}_{fb} = \alpha^2\dot{V}_{fa(1)} + \alpha\dot{V}_{fa(2)} + \dot{V}_{fa(0)} = j\left[(\alpha^2 - \alpha)X_{ff(2)} + (\alpha^2 - 1)X_{ff(0)}\right]\dot{I}_{fa(1)}$$

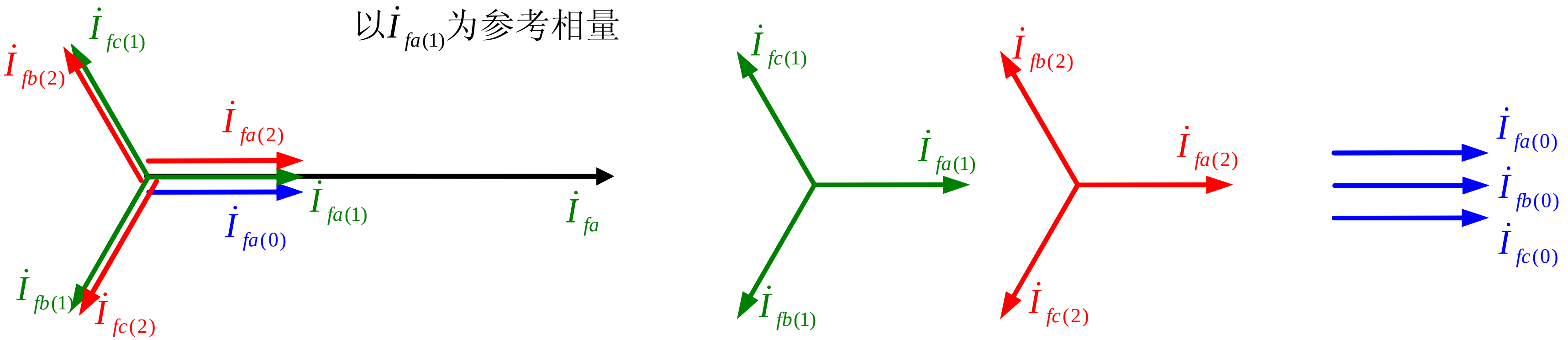
$$\dot{V}_{fc} = \alpha\dot{V}_{fa(1)} + \alpha^2\dot{V}_{fa(2)} + \dot{V}_{fa(0)} = j\left[(\alpha - \alpha^2)X_{ff(2)} + (\alpha - 1)X_{ff(0)}\right]\dot{I}_{fa(1)}$$

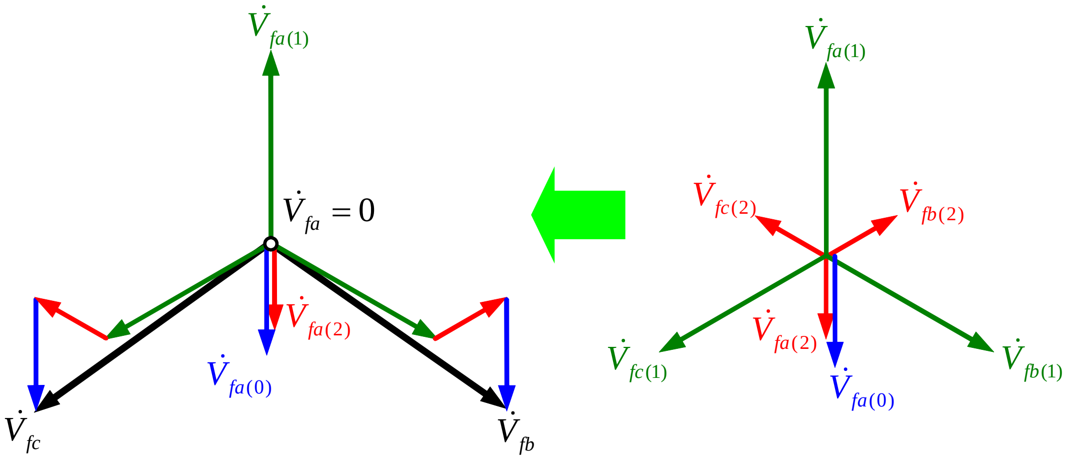
故障点处故障相电压为0，非故障相电压的幅值相等

8-1 简单不对称短路的分析

1. 单相(a相)接地短路——相量图

以$\dot{I}_{fa(1)}$为参考相量





$$\dot{V}_{fa(1)} = j\left(X_{ff(2)} + X_{ff(0)}\right)\dot{I}_{fa(1)}$$

$$\dot{V}_{fa(2)} = -jX_{ff(2)}\dot{I}_{fa(1)}$$

$$\dot{V}_{fa(0)} = -jX_{ff(0)}\dot{I}_{fa(1)}$$

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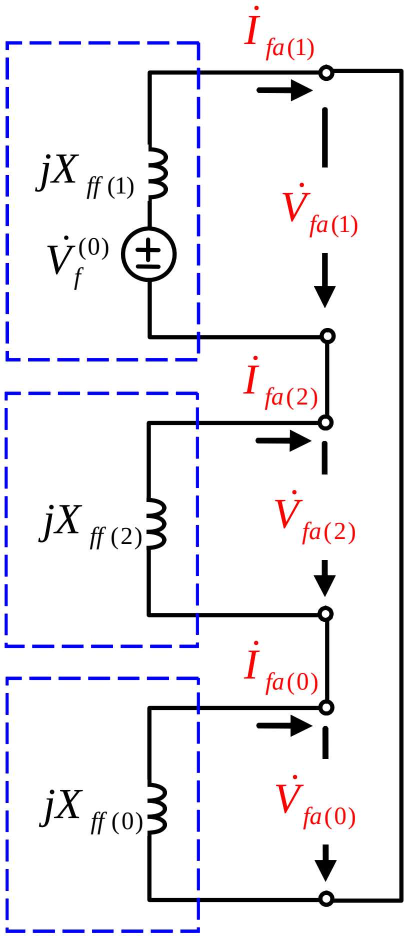
1. 单相(a相)接地短路——特例分析



$X_{ff(1)} \approx X_{ff(2)}$， $X_{ff(0)}$：与系统中性点接地情况有关

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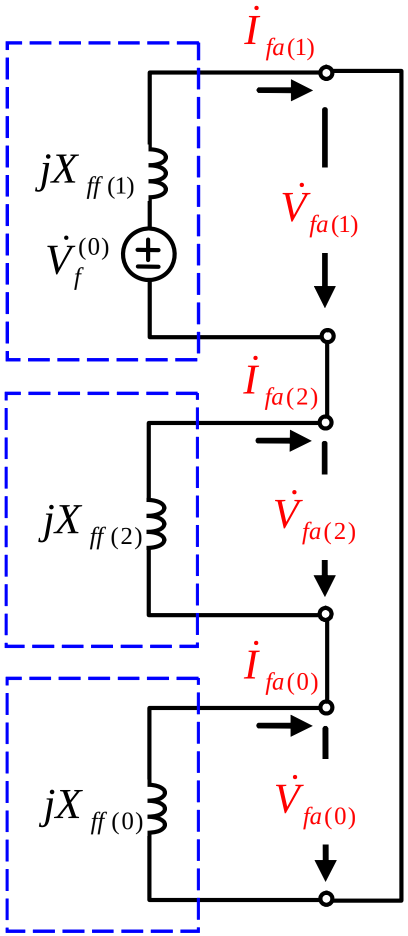

$X_{ff(1)} \approx X_{ff(2)}$， $X_{ff(0)}$：与系统中性点接地情况有关

Case I：$X_{ff(1)} > X_{ff(0)} \Rightarrow$

$$\dot{I}_f^{(1)} = \dot{I}_{fa} = \frac{3\dot{V}_f^{(0)}}{j(X_{ff(1)} + X_{ff(2)} + X_{ff(0)})} > \dot{I}_f^{(3)} = \frac{\dot{V}_f^{(0)}}{jX_{ff(1)}}$$

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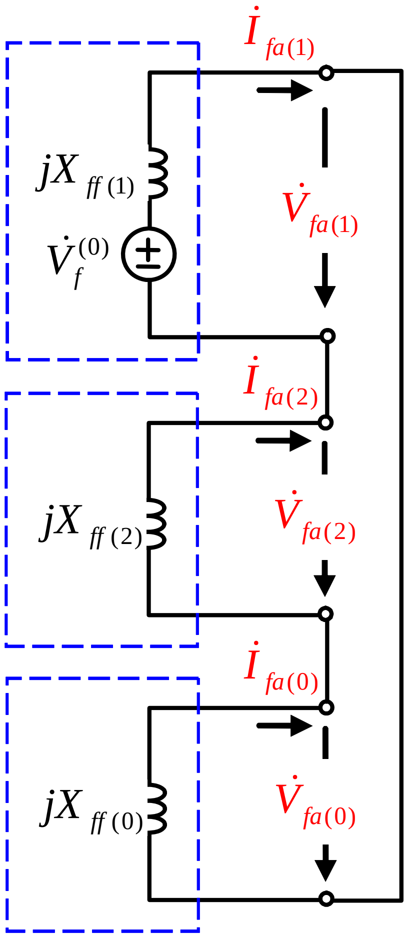

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Case II： $X_{ff(0)} \to 0$，短路点靠近中性点直接接地点

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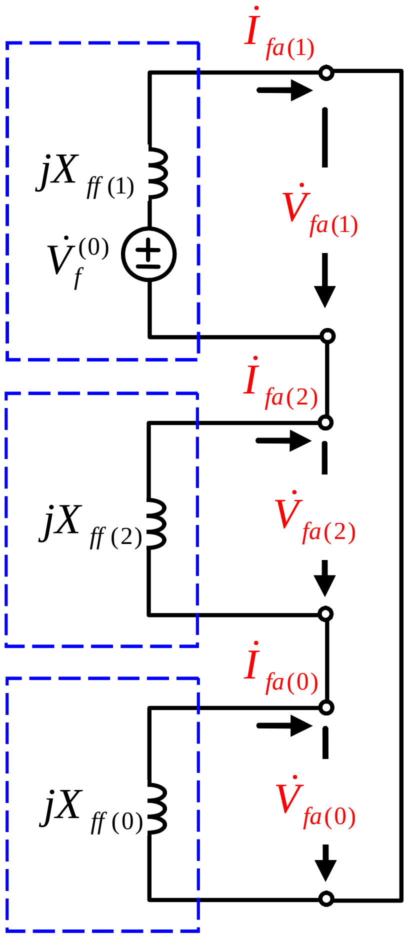

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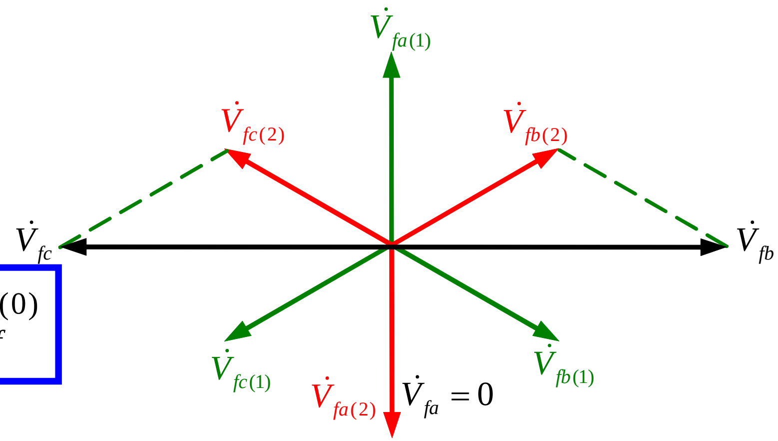
Case II： $X_{ff(0)} \to 0$， 短路点靠近中性点直接接地点

$$\dot{V}_{fa(1)} = -\dot{V}_{fa(2)} = \frac{1}{2}\dot{V}_f^0$$

$$V_{fa} = 0, \ V_{fb} = V_{fc} = \sqrt{3}/2V_f^{(0)}$$



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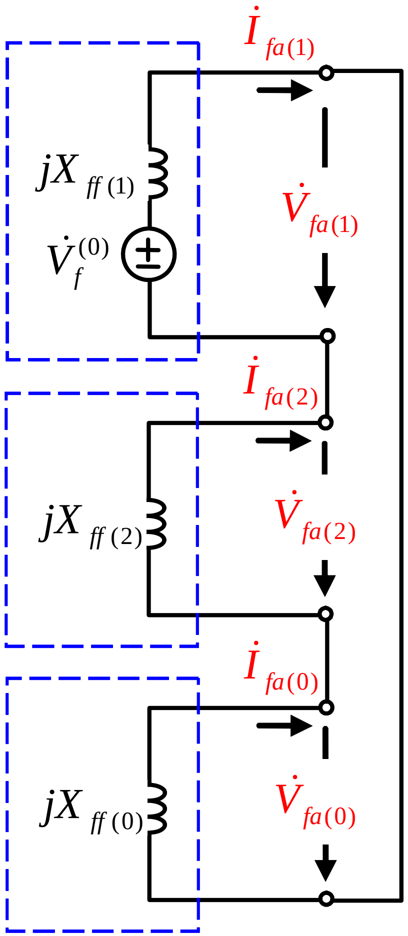

$X_{ff(1)} \approx X_{ff(2)}$， $X_{ff(0)}$：与系统中性点接地情况有关

Case III： $X_{ff(0)} \to \infty$， 中性点不接地系统

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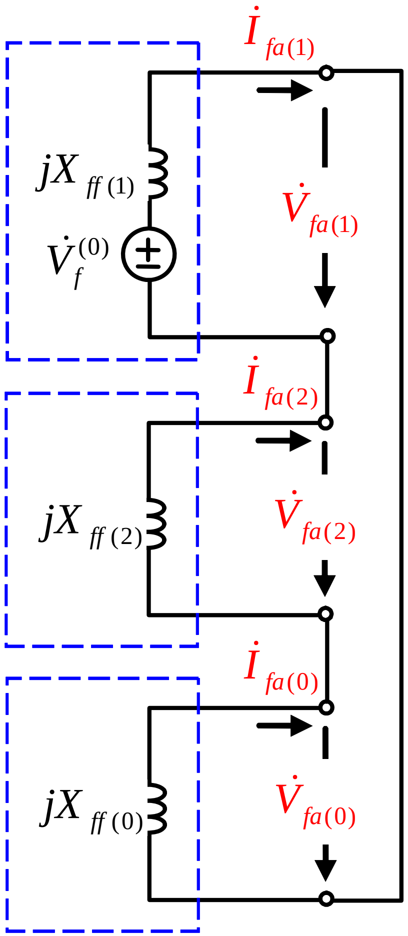

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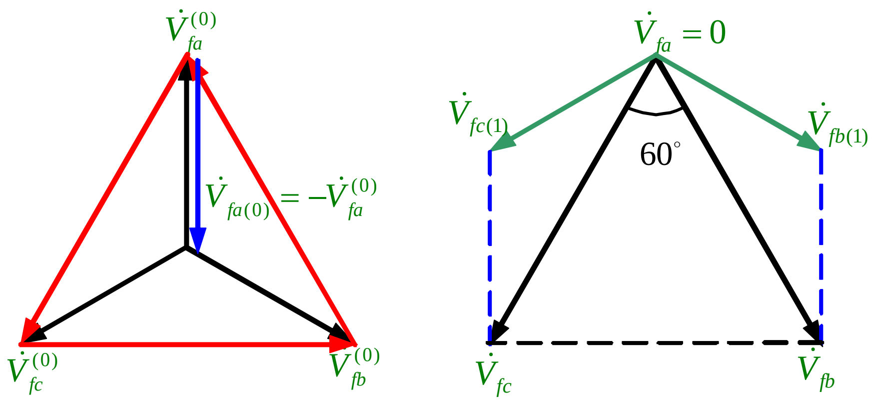
Case III： $X_{ff(0)} \to \infty$， 中性点不接地系统

$$\dot{V}_{fa(1)} = \dot{V}_f^{(0)}, \quad \dot{V}_{fa(2)} = 0, \quad \dot{V}_{fa(0)} = -\dot{V}_f^{(0)}$$

$$V_{fa} = 0, \; V_{fb} = V_{fc} = \sqrt{3} V_f^{(0)} = V_{ab}^{(0)}$$



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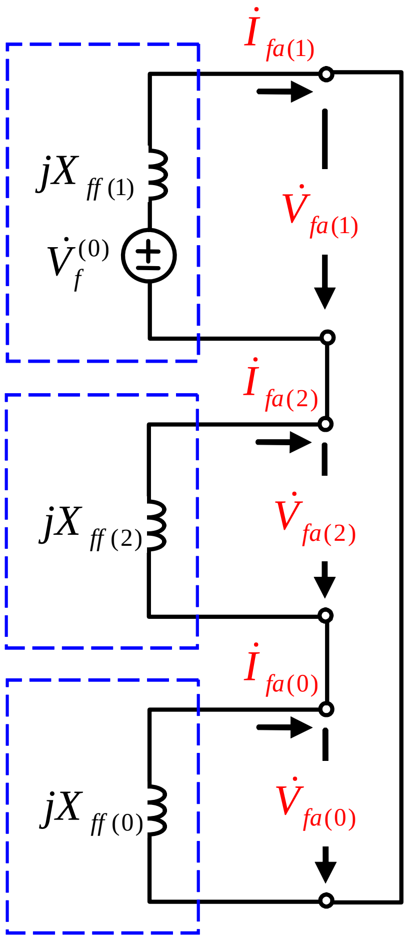
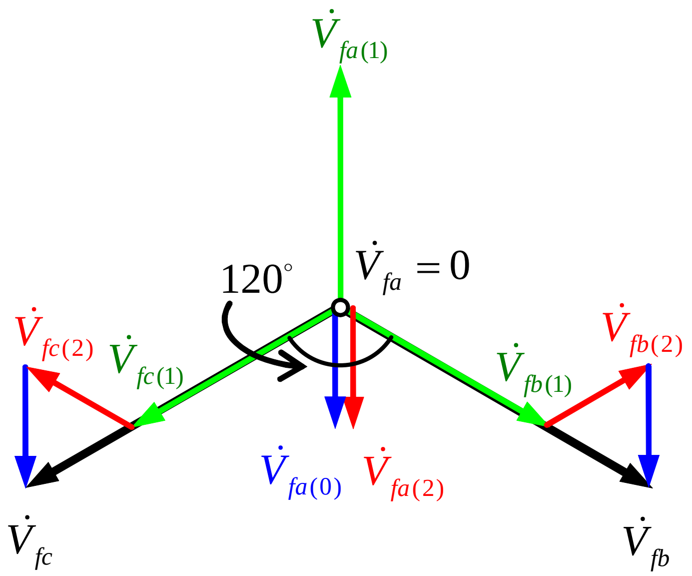


$X_{ff(1)} \approx X_{ff(2)}$， $X_{ff(0)}$： 与系统中性点接地情况有关

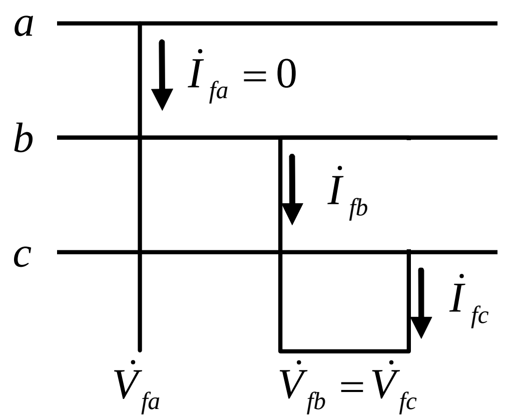
Case IV： $X_{ff(2)} = X_{ff(0)} \Rightarrow \dot{V}_{fa(2)} = \dot{V}_{fa(0)} = -\frac{1}{2}\dot{V}_{fa(1)}$



8-1 简单不对称短路的分析

2. 两相(b相和c相)短路——序分量边界条件

(1)相量表示的边界条件：$\dot{V}_{fb}=\dot{V}_{fc},\ \dot{I}_{fa}=0,\ \dot{I}_{fb}+\dot{I}_{fc}=0$



8-1 简单不对称短路的分析

2. 两相(b相和c相)短路——序分量边界条件

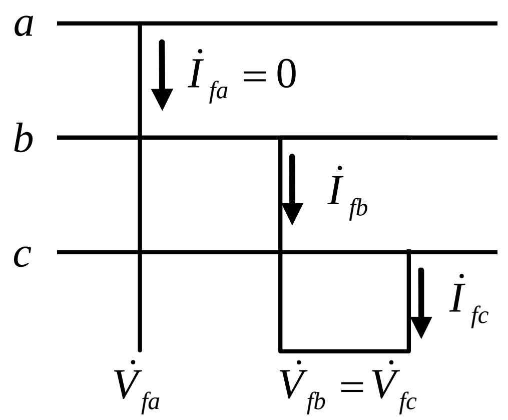
(1)相量表示的边界条件：$\dot{V}_{fb}=\dot{V}_{fc},\ \dot{I}_{fa}=0,\ \dot{I}_{fb}+\dot{I}_{fc}=0$

(2) 对称分量表示的边界条件

$$\dot{V}_{fb(1)}+\dot{V}_{fb(2)}+\dot{V}_{fb(0)}=\dot{V}_{fc(1)}+\dot{V}_{fc(2)}+\dot{V}_{fc(0)}$$

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

$$\dot{I}_{fb(1)}+\dot{I}_{fb(2)}+\dot{I}_{fb(0)}+\dot{I}_{fc(1)}+\dot{I}_{fc(2)}+\dot{I}_{fc(0)}=0$$



8-1 简单不对称短路的分析

2. 两相(b相和c相)短路——序分量边界条件

(1)相量表示的边界条件：$\dot{V}_{fb}=\dot{V}_{fc},\ \dot{I}_{fa}=0,\ \dot{I}_{fb}+\dot{I}_{fc}=0$

(2) 对称分量表示的边界条件

$$\dot{V}_{fb(1)}+\dot{V}_{fb(2)}+\dot{V}_{fb(0)}=\dot{V}_{fc(1)}+\dot{V}_{fc(2)}+\dot{V}_{fc(0)}$$

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

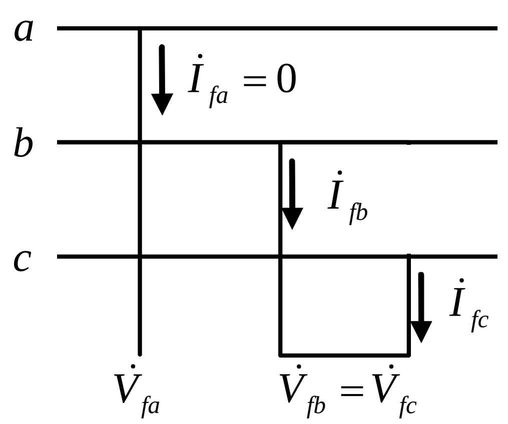
$$\dot{I}_{fb(1)}+\dot{I}_{fb(2)}+\dot{I}_{fb(0)}+\dot{I}_{fc(1)}+\dot{I}_{fc(2)}+\dot{I}_{fc(0)}=0$$

(3) 以a相为参考相

$$(\alpha^2-\alpha)\dot{V}_{fa(1)}+(\alpha-\alpha^2)\dot{V}_{fa(2)}=0$$

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

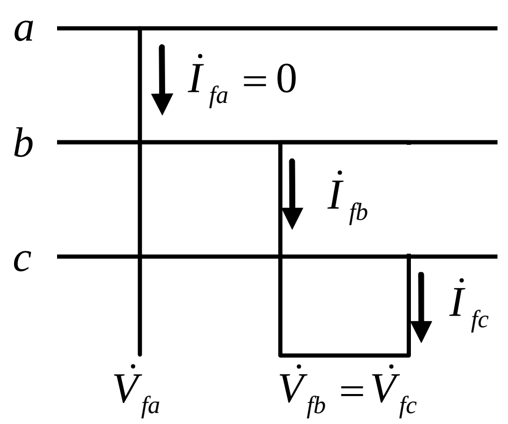
$$(\alpha^2+\alpha)\dot{I}_{fa(1)}+(\alpha^2+\alpha)\dot{I}_{fa(2)}+2\dot{I}_{fa(0)}=0$$



8-1 简单不对称短路的分析

2. 两相(b相和c相)短路——序分量边界条件

(1)相量表示的边界条件：$\dot{V}_{fb}=\dot{V}_{fc},\ \dot{I}_{fa}=0,\ \dot{I}_{fb}+\dot{I}_{fc}=0$



(2) 对称分量表示的边界条件

$$\dot{V}_{fb(1)}+\dot{V}_{fb(2)}+\dot{V}_{fb(0)}=\dot{V}_{fc(1)}+\dot{V}_{fc(2)}+\dot{V}_{fc(0)}$$

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

$$\dot{I}_{fb(1)}+\dot{I}_{fb(2)}+\dot{I}_{fb(0)}+\dot{I}_{fc(1)}+\dot{I}_{fc(2)}+\dot{I}_{fc(0)}=0$$

(3) 以a相为参考相

$$(\alpha^2-\alpha)\dot{V}_{fa(1)}+(\alpha-\alpha^2)\dot{V}_{fa(2)}=0$$

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

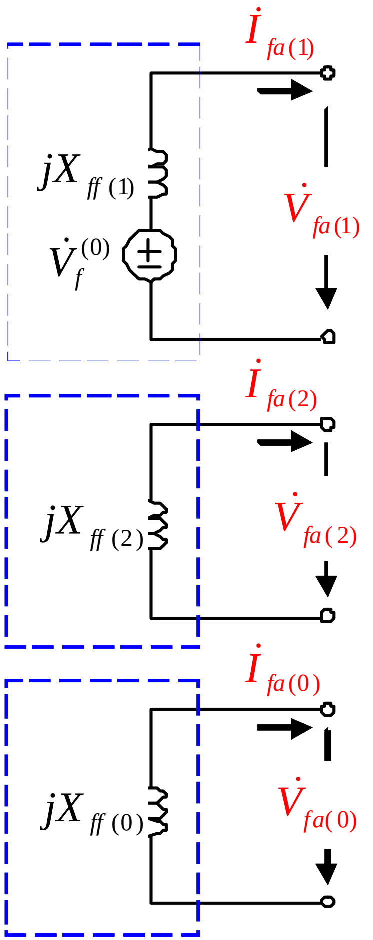
$$(\alpha^2+\alpha)\dot{I}_{fa(1)}+(\alpha^2+\alpha)\dot{I}_{fa(2)}+2\dot{I}_{fa(0)}=0$$

(4) 序分量边界条件：

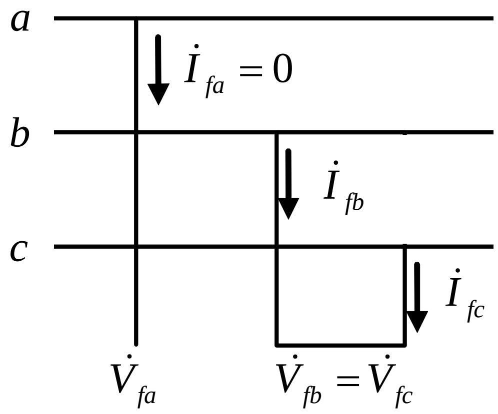
$$\left.\begin{aligned}&\dot{V}_{fa(1)}=\dot{V}_{fa(2)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}=0\\&\dot{I}_{fa(0)}=0\end{aligned}\right\}\text{(8-7)}$$

8-1 简单不对称短路的分析

2. 两相(b相和c相)短路——复合序网

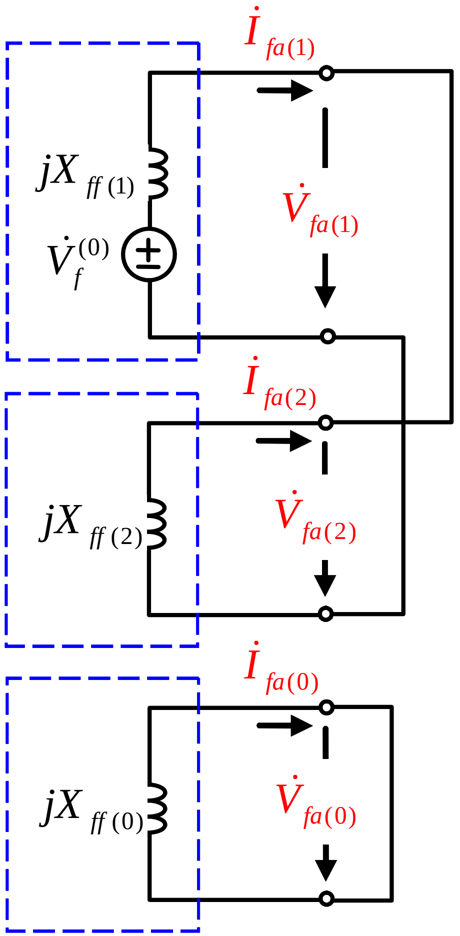


$$\boxed{\left.\begin{aligned} &\dot{V}_{fa(1)} = \dot{V}_{fa(2)}, \\ &\dot{I}_{fa(1)} + \dot{I}_{fa(2)} = 0 \\ &\dot{I}_{fa(0)} = 0 \end{aligned}\right\} (8-7)}$$

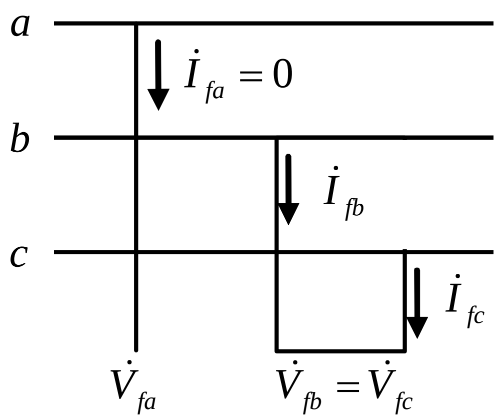


8-1 简单不对称短路的分析

2. 两相(b相和c相)短路——复合序网

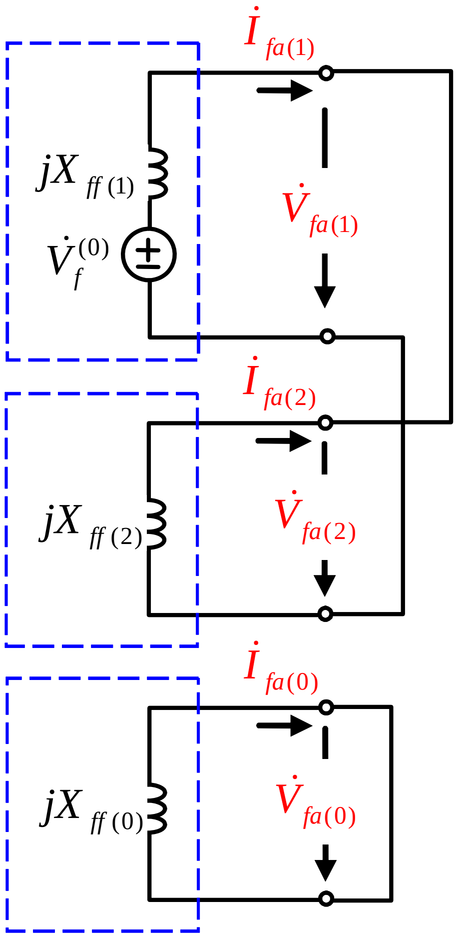


$$\left.\begin{aligned}&\dot{V}_{fa(1)}=\dot{V}_{fa(2)},\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}=0\\&\dot{I}_{fa(0)}=0\end{aligned}\right\}(8-7)$$



8-1 简单不对称短路的分析

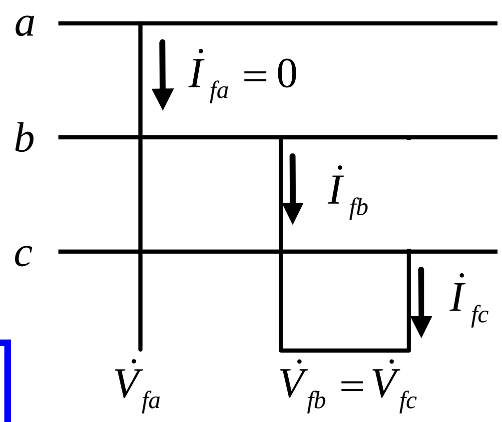
2. 两相(b相和c相)短路——复合序网



$$\left.\begin{aligned} &\dot V_{fa(1)} = \dot V_{fa(2)}, \\ &\dot I_{fa(1)} + \dot I_{fa(2)} = 0 \\ &\dot I_{fa(0)} = 0 \end{aligned}\right\}(8-7)$$

$$\dot I_{fa(1)} = \frac{\dot V_f^{(0)}}{j(X_{ff(1)} + X_{ff(2)})} \quad (8-8)$$

$$\left.\begin{aligned} &\dot I_{fa(2)} = -\dot I_{fa(1)} \\ &\dot V_{fa(1)} = \dot V_{fa(2)} = jX_{ff(2)}\dot I_{fa(1)} \\ &\dot V_{fa(0)} = -jX_{ff(0)}\dot I_{fa(0)} = 0 \end{aligned}\right\}(8-9)$$



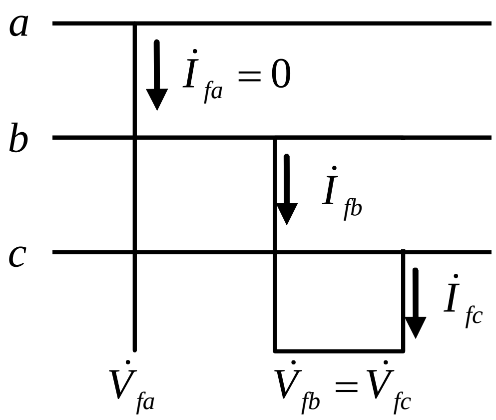
8-1 简单不对称短路的分析

2. 两相(b相和c相)短路——故障点各相电流电压

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

$$\dot{I}_{fb}=\alpha^2\dot{I}_{fa(1)}+\alpha\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=(\alpha^2-\alpha)\dot{I}_{fa(1)}=-j\sqrt{3}\dot{I}_{fa(1)}$$

$$\dot{I}_{fc}=-\dot{I}_{fb}=j\sqrt{3}\dot{I}_{fa(1)}$$



$$\dot{V}_{fa}=\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=2\dot{V}_{fa(1)}=j2X_{ff(2)}\dot{I}_{fa(1)}$$

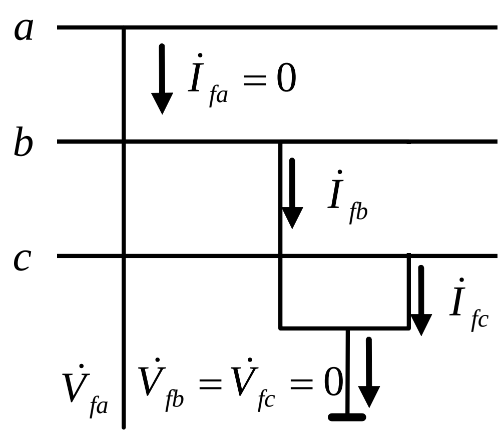
$$\dot{V}_{fb}=\alpha^2\dot{V}_{fa(1)}+\alpha\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=-\dot{V}_{fa(1)}=\dot{V}_{fa}/2$$

$$\dot{V}_{fc}=\alpha\dot{V}_{fa(1)}+\alpha^2\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=-\dot{V}_{fa(1)}=\dot{V}_{fa}/2$$

8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——序分量边界条件

(1)相量表示的边界条件：$\dot{V}_{fb}=\dot{V}_{fc}=0,\ \dot{I}_{fa}=0$



8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——序分量边界条件

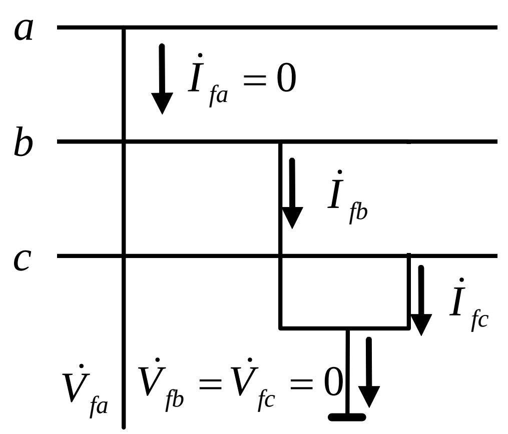
(1)相量表示的边界条件：$\dot{V}_{fb}=\dot{V}_{fc}=0,\ \dot{I}_{fa}=0$

(2) 对称分量表示的边界条件

$$\dot{V}_{fb(1)}+\dot{V}_{fb(2)}+\dot{V}_{fb(0)}=0$$

$$\dot{V}_{fc(1)}+\dot{V}_{fc(2)}+\dot{V}_{fc(0)}=0$$

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



8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——序分量边界条件

(1)相量表示的边界条件：$\dot{V}_{fb}=\dot{V}_{fc}=0,\ \dot{I}_{fa}=0$

(2) 对称分量表示的边界条件

$$\dot{V}_{fb(1)}+\dot{V}_{fb(2)}+\dot{V}_{fb(0)}=0$$

$$\dot{V}_{fc(1)}+\dot{V}_{fc(2)}+\dot{V}_{fc(0)}=0$$

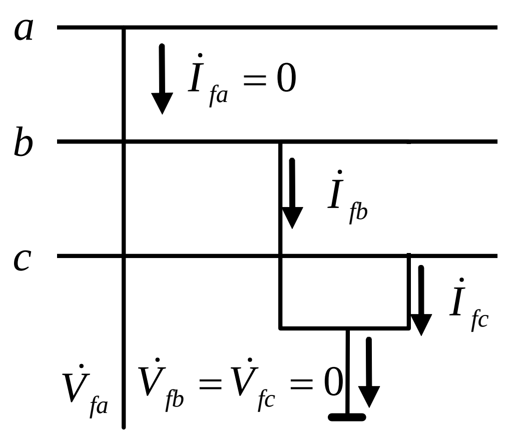
$$\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$

(3) 以a相为参考相

$$\alpha^2\dot{V}_{fa(1)}+\alpha\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0$$

$$\alpha\dot{V}_{fa(1)}+\alpha^2\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0$$

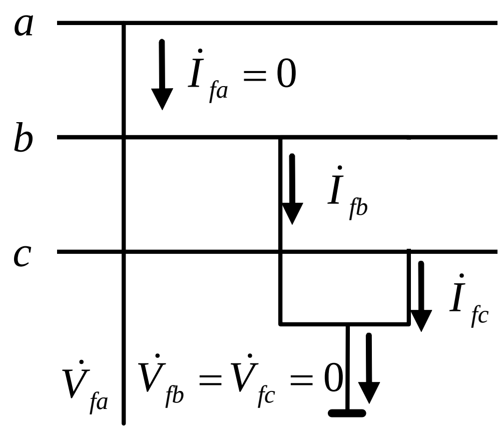
$$\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$



8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——序分量边界条件

(1)相量表示的边界条件：$\dot{V}_{fb}=\dot{V}_{fc}=0,\ \dot{I}_{fa}=0$



(2) 对称分量表示的边界条件

$$\dot{V}_{fb(1)}+\dot{V}_{fb(2)}+\dot{V}_{fb(0)}=0$$
$$\dot{V}_{fc(1)}+\dot{V}_{fc(2)}+\dot{V}_{fc(0)}=0$$
$$\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$

(3) 以a相为参考相

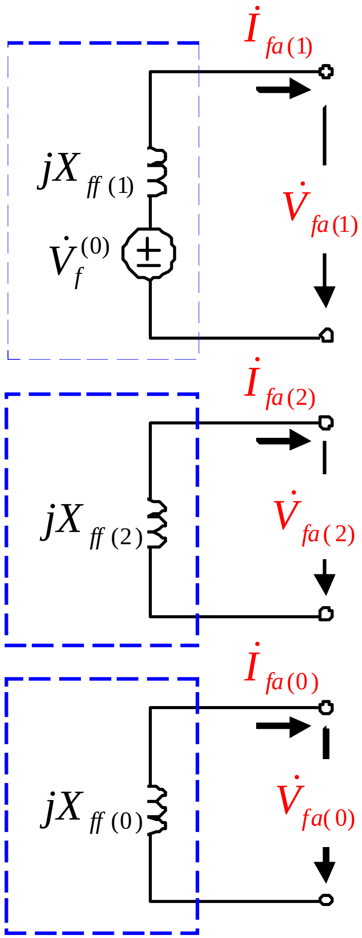
$$\alpha^2\dot{V}_{fa(1)}+\alpha\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0$$
$$\alpha\dot{V}_{fa(1)}+\alpha^2\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=0$$
$$\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$

(4) 序分量边界条件：

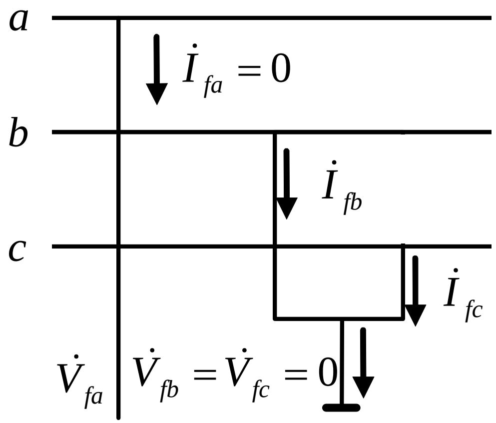
$$\left.\begin{aligned}&\dot{V}_{fa(1)}=\dot{V}_{fa(2)}=\dot{V}_{fa(0)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0\end{aligned}\right\}\text{(8-13)}$$

8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——复合序网

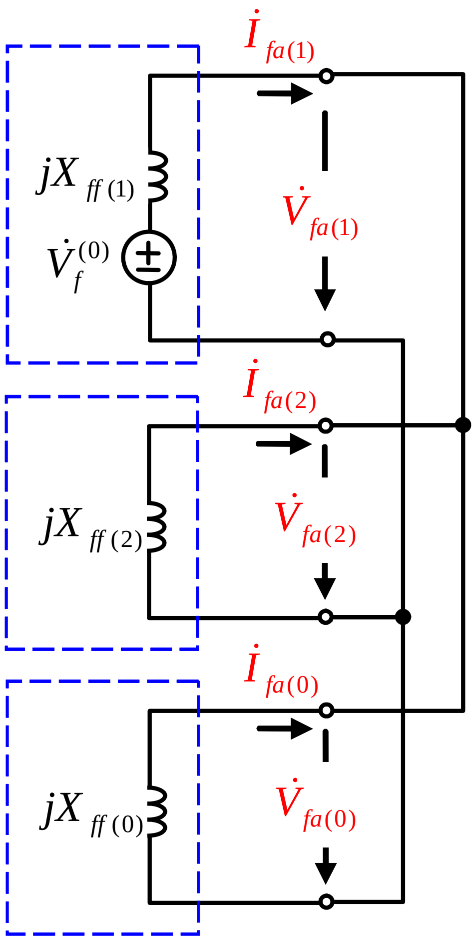


$$\left.\begin{array}{l}\dot{V}_{fa(1)}=\dot{V}_{fa(2)}=\dot{V}_{fa(0)}\\ \dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0\end{array}\right\}(8\text{-}13)$$

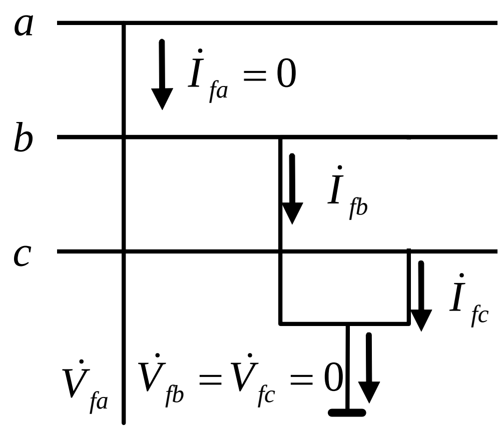


8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——复合序网

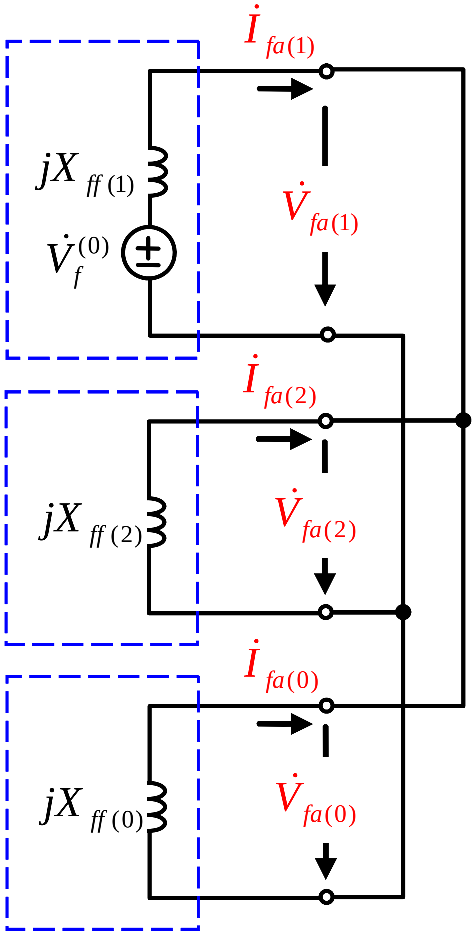


$$\boxed{\left.\begin{aligned}&\dot{V}_{fa(1)}=\dot{V}_{fa(2)}=\dot{V}_{fa(0)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0\end{aligned}\right\}\text{(8-13)}}$$



8-1 简单不对称短路的分析

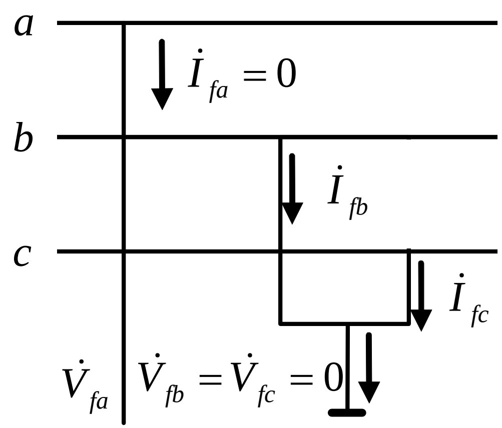
3. 两相(b相和c相)短路接地——复合序网



$$\left.\begin{aligned}&\dot{V}_{fa(1)}=\dot{V}_{fa(2)}=\dot{V}_{fa(0)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0\end{aligned}\right\}(8\text{-}13)$$

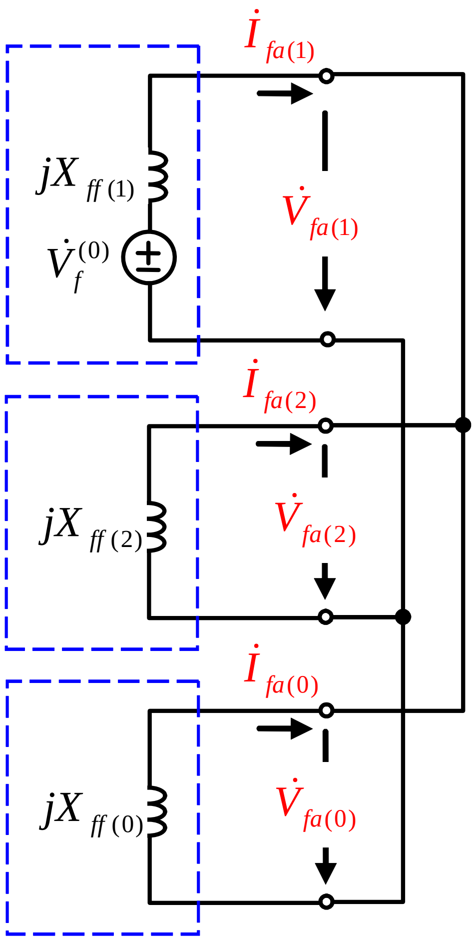
$$\dot{I}_{fa(1)}=\frac{\dot{V}_f^{(0)}}{j(X_{ff(1)}+X_{ff(2)}//X_{ff(0)})}$$

$$\left.\begin{aligned}&\dot{I}_{fa(2)}=-\frac{X_{ff(0)}}{X_{ff(2)}+X_{ff(0)}}\dot{I}_{fa(1)}\\&\dot{I}_{fa(0)}=-\frac{X_{ff(2)}}{X_{ff(2)}+X_{ff(0)}}\dot{I}_{fa(1)}\end{aligned}\right\}$$



8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——复合序网

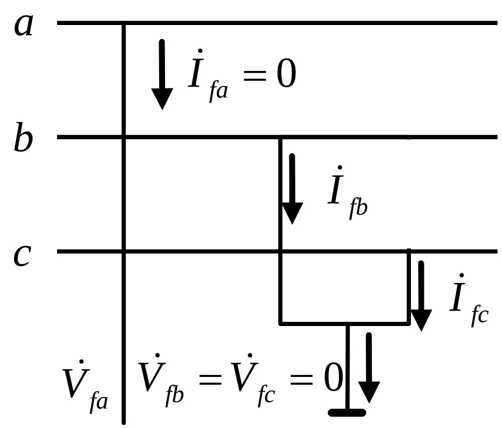


$$\left.\begin{aligned}&\dot{V}_{fa(1)}=\dot{V}_{fa(2)}=\dot{V}_{fa(0)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0\end{aligned}\right\}\text{(8-13)}$$

$$\dot{I}_{fa(1)}=\frac{\dot{V}_f^{(0)}}{j(X_{ff(1)}+X_{ff(2)}//X_{ff(0)})}$$

$$\left.\begin{aligned}&\dot{I}_{fa(2)}=-\frac{X_{ff(0)}}{X_{ff(2)}+X_{ff(0)}}\dot{I}_{fa(1)}\\&\dot{I}_{fa(0)}=-\frac{X_{ff(2)}}{X_{ff(2)}+X_{ff(0)}}\dot{I}_{fa(1)}\end{aligned}\right\}$$

$$\dot{V}_{fa(1)}=\dot{V}_{fa(2)}=\dot{V}_{fa(0)}=j\frac{X_{ff(2)}X_{ff(0)}}{X_{ff(2)}+X_{ff(0)}}\dot{I}_{fa(1)}$$



8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——故障点各相电流电压

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

$$\dot{I}_{fb}=\alpha^2\dot{I}_{fa(1)}+\alpha\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=\left(\alpha^2-\frac{X_{ff(2)}+\alpha X_{ff(0)}}{X_{ff(2)}+X_{ff(0)}}\right)\dot{I}_{fa(1)}$$

$$\dot{I}_{fc}=\alpha\dot{I}_{fa(1)}+\alpha^2\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=\left(\alpha-\frac{X_{ff(2)}+\alpha^2 X_{ff(0)}}{X_{ff(2)}+X_{ff(0)}}\right)\dot{I}_{fa(1)}$$

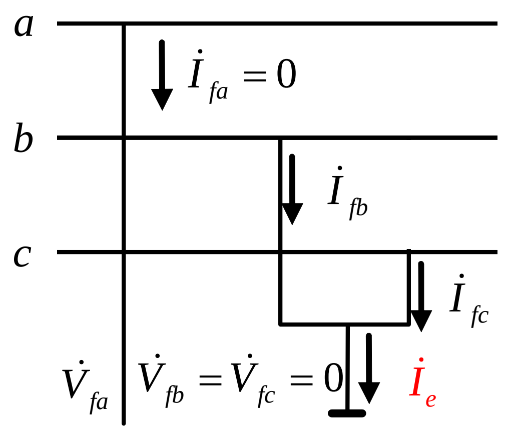
$$\dot{V}_{fa}=\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=3\dot{V}_{fa(1)}=j\frac{X_{ff(2)}X_{ff(0)}}{X_{ff(2)}+X_{ff(0)}}\dot{I}_{fa(1)}$$

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

8-1 简单不对称短路的分析

3. 两相(b相和c相)短路接地——故障点入地电流

$$\boxed{\dot{I}_{e}=3\dot{I}_{fa(0)}=\dot{I}_{fb}+\dot{I}_{fc}=-3\frac{X_{ff(2)}}{X_{ff(2)}+X_{ff(0)}}\dot{I}_{fa(1)}}$$



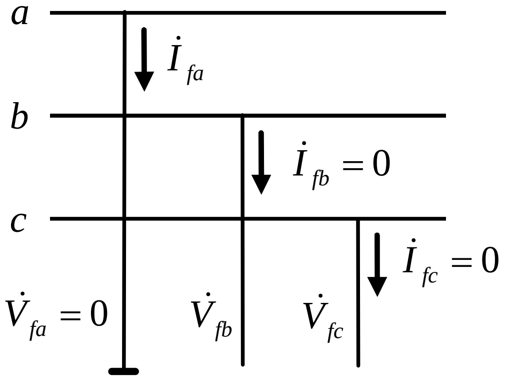
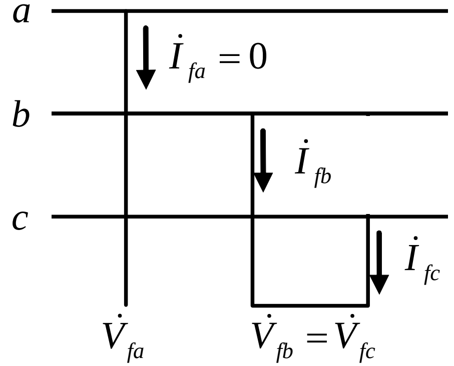
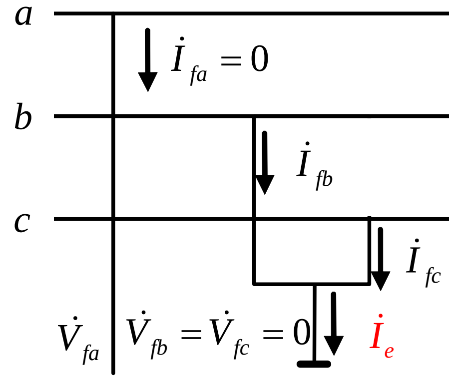
8-1 简单不对称短路的分析——小结

简单不对称短路的分析方法小结

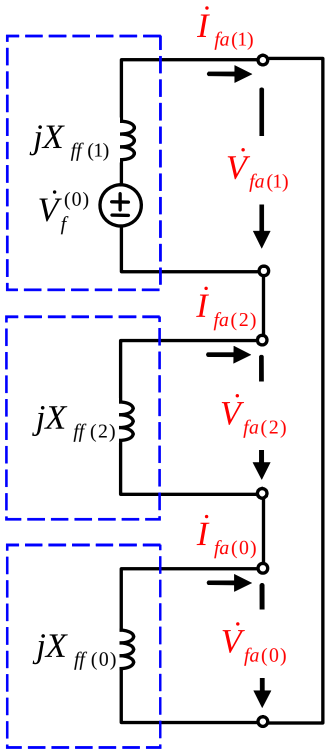
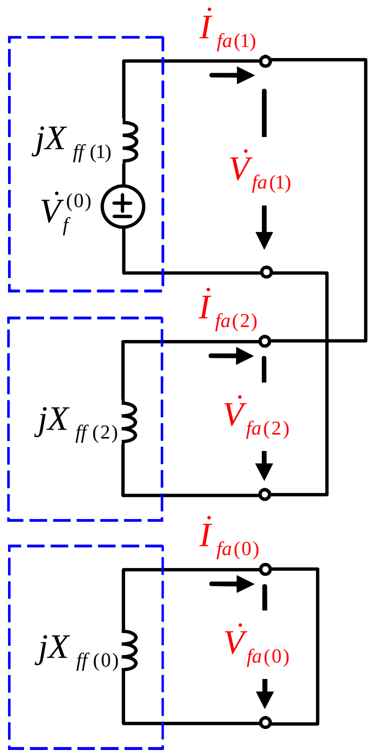
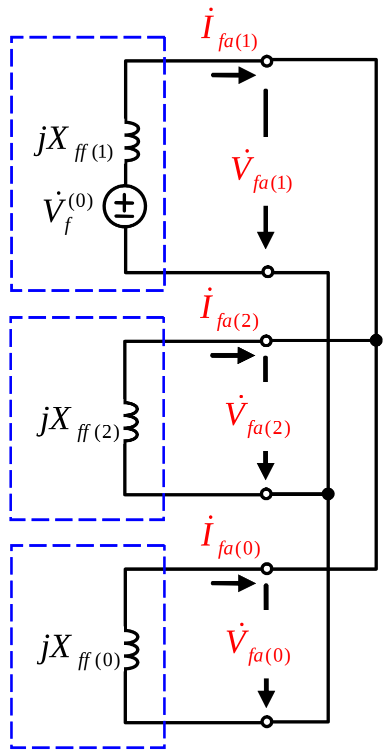
- 制定各序网络；根据系统运行方式确定故障口正常电压、各序输入阻抗，建立序网方程；(Chapter 7)
- 根据故障情况选取参考相，确定用序分量表示的边界条件；
- 由序网方程和序分量边界条件求解故障口电流电压各序分量(复合序网、方程求解等)；
- 对电流电压各序分量进行综合即可得到故障口的电流和电压相量。

8-1 简单不对称短路的分析——序分量边界条件

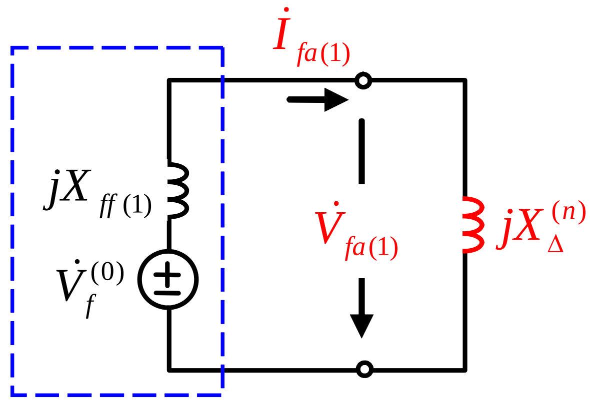
(1)关于故障特殊相和参考相——使序分量边界条件表达式简单

$f^{(1)}$	$f^{(2)}$	$f^{(1,1)}$
		
$\left.\begin{aligned}\dot V_{fa(1)}+\dot V_{fa(2)}+\dot V_{fa(0)}=0\\ \dot I_{fa(1)}=\dot I_{fa(2)}=\dot I_{fa(0)}\end{aligned}\right\}$	$\left.\begin{aligned}\dot V_{fa(1)}=\dot V_{fa(2)}\\ \dot I_{fa(1)}+\dot I_{fa(2)}=0,\dot I_{fa(0)}=0\end{aligned}\right\}$	$\left.\begin{aligned}\dot V_{fa(1)}=\dot V_{fa(2)}=\dot V_{fa(0)}\\ \dot I_{fa(1)}+\dot I_{fa(2)}+\dot I_{fa(0)}=0\end{aligned}\right\}$

8-1 简单不对称短路的分析——复合序网

<table>
<tr><th>$f^{(1)}$</th><th>$f^{(2)}$</th><th>$f^{(1,1)}$</th></tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\dot I_{fa(1)} = \dfrac{\dot V_f^{(0)}}{j(X_{ff(1)} + X_{ff(2)} + X_{ff(0)})}$</td>
<td>$\dot I_{fa(1)} = \dfrac{\dot V_f^{(0)}}{j(X_{ff(1)} + X_{ff(2)})}$</td>
<td>$\dot I_{fa(1)} = \dfrac{\dot V_f^{(0)}}{j(X_{ff(1)} + X_{ff(2)} // X_{ff(0)})}$</td>
</tr>
</table>

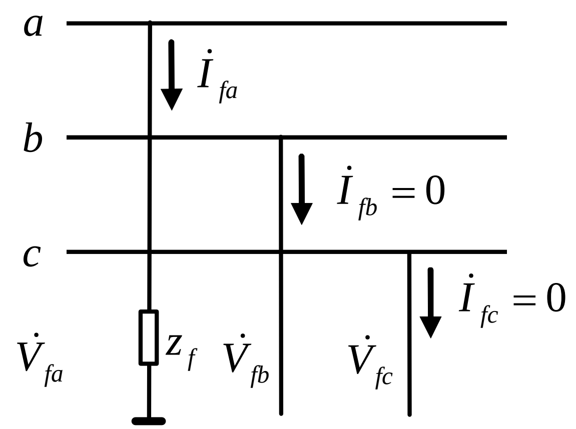
8-1 简单不对称短路的分析——正序等效定则

故障类型	附加电抗 $X_{\Delta}^{(n)}$	复合序网
$f^{(3)}$	0	
$f^{(1)}$	$X_{ff(2)} + X_{ff(0)}$	
$f^{(2)}$	$X_{ff(2)}$	
$f^{(1,1)}$	$X_{ff(2)} // X_{ff(0)}$	$\dot{I}_{fa(1)}^{(n)} = \dfrac{\dot{V}_f^{(0)}}{j(X_{ff(1)} + X_{\Delta}^{(n)})}$

8-1 简单不对称短路的分析——非金属性短路

(1) 单相(a相)非金属性接地短路——序分量边界条件

(1)相量表示的边界条件：$\dot V_{fa}=z_f\dot I_{fa},\ \dot I_{fb}=0,\ \dot I_{fc}=0$



(2) 对称分量表示的边界条件

$$\dot V_{fa}=\dot V_{fa(1)}+\dot V_{fa(2)}+\dot V_{fa(0)}=z_f(\dot I_{fa(1)}+\dot I_{fa(2)}+\dot I_{fa(0)})$$

$$\dot I_{fb}=\dot I_{fb(1)}+\dot I_{fb(2)}+\dot I_{fb(0)}=0$$

$$\dot I_{fc}=\dot I_{fc(1)}+\dot I_{fc(2)}+\dot I_{fc(0)}=0$$

(3) 以a相为参考相

$$\dot V_{fa}=\dot V_{fa(1)}+\dot V_{fa(2)}+\dot V_{fa(0)}=z_f(\dot I_{fa(1)}+\dot I_{fa(2)}+\dot I_{fa(0)})$$

$$\dot I_{fb}=\alpha^2\dot I_{fa(1)}+\alpha\dot I_{fa(2)}+\dot I_{fa(0)}=0$$

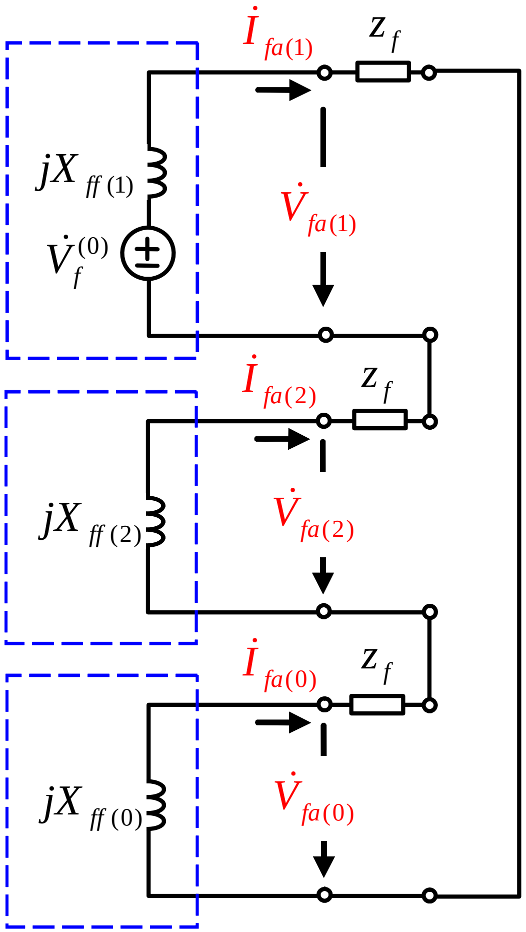
$$\dot I_{fc}=\alpha\dot I_{fa(1)}+\alpha^2\dot I_{fa(2)}+\dot I_{fa(0)}=0$$

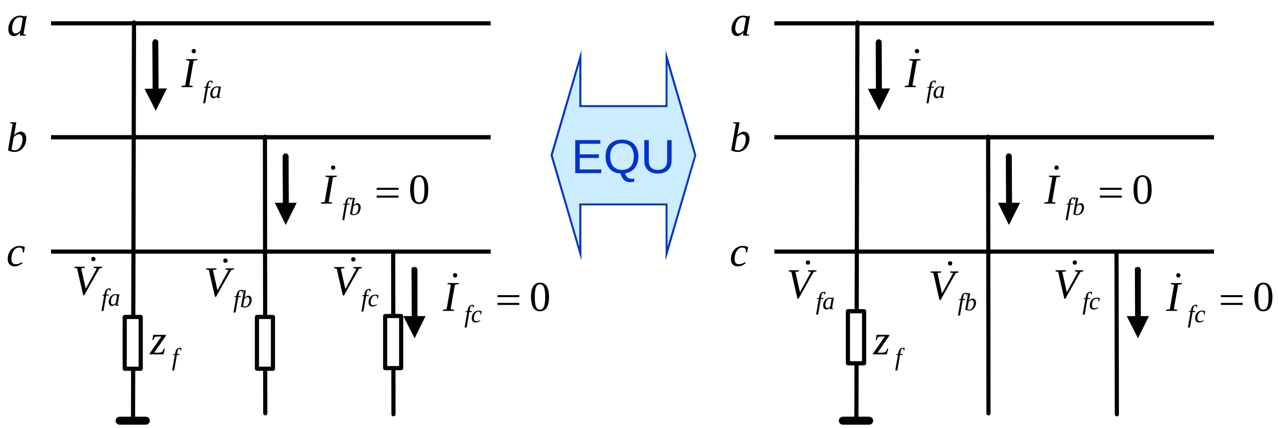
(4) 序分量边界条件：

$$\left.\begin{aligned}&\dot V_{fa(1)}+\dot V_{fa(2)}+\dot V_{fa(0)}=3z_f\dot I_{fa(1)}\\&\dot I_{fa(1)}=\dot I_{fa(2)}=\dot I_{fa(0)}\end{aligned}\right\}$$

8-1 简单不对称短路的分析——非金属性短路

(1) 单相(a相)非金属性接地短路——复合序网





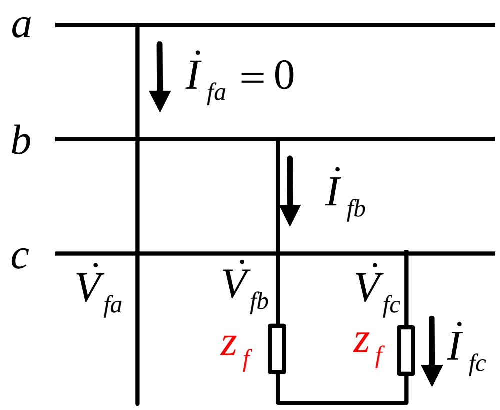
$$\left.\begin{array}{l}\dot{V}_{fa(1)}+\dot{V}_{fa(2)}+\dot{V}_{fa(0)}=3z_f\dot{I}_{fa(1)}\\ \dot{I}_{fa(1)}=\dot{I}_{fa(2)}=\dot{I}_{fa(0)}\end{array}\right\}$$

8-1 简单不对称短路的分析——非金属性短路

(2) 两相(b相和c相)非金属性短路——序分量边界条件

$$\dot{V}_{fb}-z_f\dot{I}_{fb}=\dot{V}_{fc}-z_f\dot{I}_{fc},\ \dot{I}_{fa}=0,\dot{I}_{fb}+\dot{I}_{fc}=0$$

$$\dot{V}_{fb(1)}+\dot{V}_{fb(2)}+\dot{V}_{fb(0)}-z_f(\dot{I}_{fb(1)}+\dot{I}_{fb(2)}+\dot{I}_{fb(0)})$$
$$=\dot{V}_{fc(1)}+\dot{V}_{fc(2)}+\dot{V}_{fc(0)}-z_f(\dot{I}_{fc(1)}+\dot{I}_{fc(2)}+\dot{I}_{fc(0)})$$
$$\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$
$$\dot{I}_{fb(1)}+\dot{I}_{fb(2)}+\dot{I}_{fb(0)}+\dot{I}_{fc(1)}+\dot{I}_{fc(2)}+\dot{I}_{fc(0)}=0$$



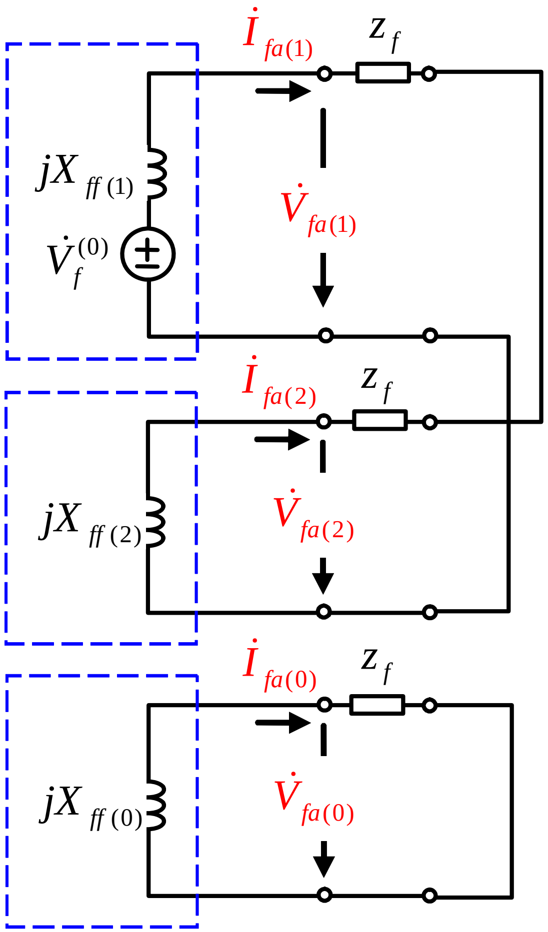
$$(\alpha^2-\alpha)\dot{V}_{fa(1)}+(\alpha-\alpha^2)\dot{V}_{fa(2)}$$
$$=z_f\left[(\alpha^2-\alpha)\dot{I}_{fa(1)}+(\alpha-\alpha^2)\dot{I}_{fa(2)}\right]$$
$$\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$
$$(\alpha^2+\alpha)\dot{I}_{fa(1)}+(\alpha^2+\alpha)\dot{I}_{fa(2)}+2\dot{I}_{fa(0)}=0$$

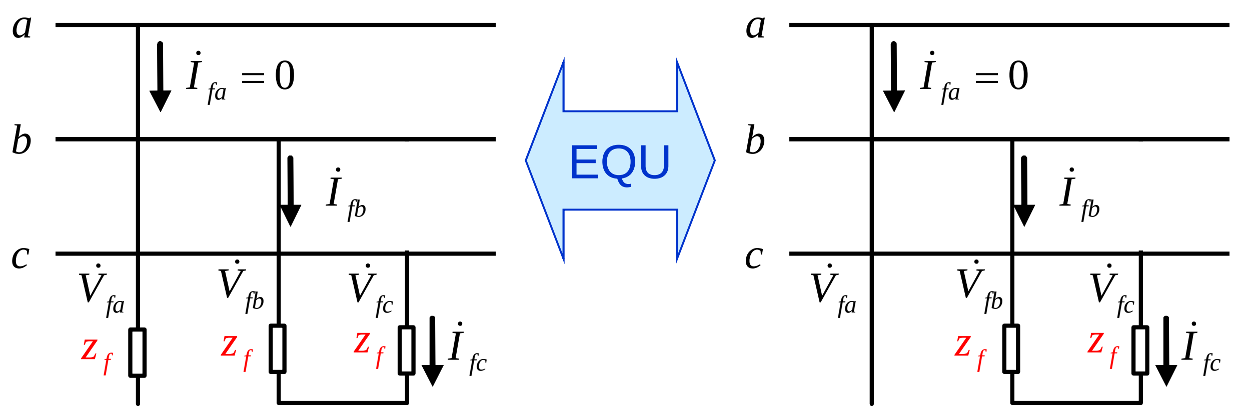
(4) 序分量边界条件：

$$\left.\begin{aligned}&\dot{V}_{fa(1)}-z_f\dot{I}_{fa(1)}=\dot{V}_{fa(2)}-z_f\dot{I}_{fa(1)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}=0,\dot{I}_{fa(0)}=0\end{aligned}\right\}$$

8-1 简单不对称短路的分析——非全属性短路

(2) 两相(b相和c相)非全属性短路——复合序网



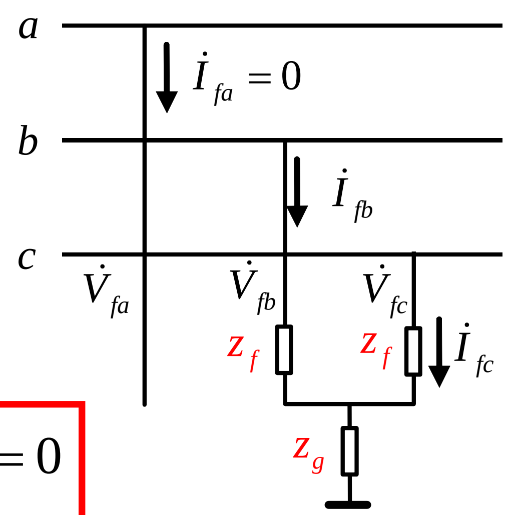


序分量边界条件：

$$\left.\begin{aligned}&\dot{V}_{fa(1)}-z_f\dot{I}_{fa(1)}=\dot{V}_{fa(2)}-z_f\dot{I}_{fa(2)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}=0,\dot{I}_{fa(0)}=0\end{aligned}\right\}$$

8-1 简单不对称短路的分析——非金属性短路

(3) 两相(b相和c相)非金属性短路接地——序分量边界条件



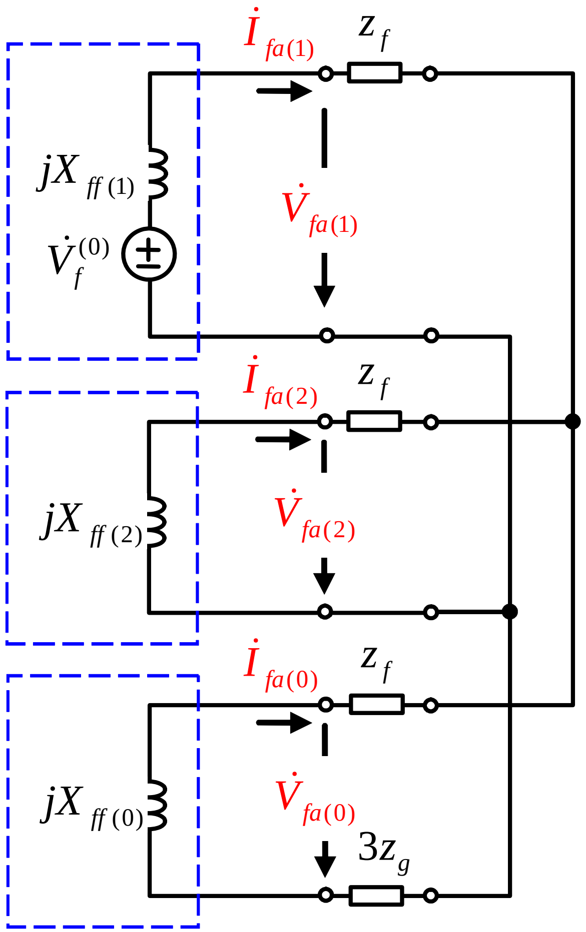
$$\dot{I}_{fa}=0$$
$$\dot{V}_{fb}-z_f\dot{I}_{fb}-z_g(\dot{I}_{fb}+\dot{I}_{fc})=0$$
$$\dot{V}_{fc}-z_f\dot{I}_{fc}-z_g(\dot{I}_{fb}+\dot{I}_{fc})=0$$

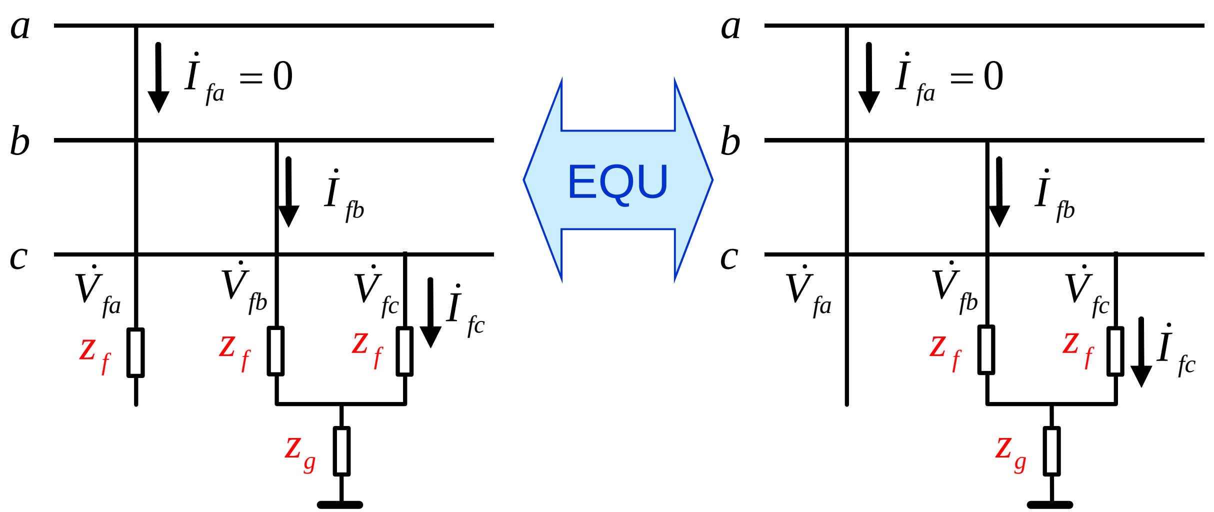
$$\alpha^2\dot{V}_{fa(1)}+\alpha\dot{V}_{fa(2)}+\dot{V}_{fa(0)}-z_f(\alpha^2\dot{I}_{fa(1)}+\alpha\dot{I}_{fa(2)}+\dot{I}_{fa(0)})-3z_g\dot{I}_{fa(0)}=0$$
$$\alpha\dot{V}_{fa(1)}+\alpha^2\dot{V}_{fa(2)}+\dot{V}_{fa(0)}-z_f(\alpha\dot{I}_{fa(1)}+\alpha^2\dot{I}_{fa(2)}+\dot{I}_{fa(0)})-3z_g\dot{I}_{fa(0)}=0$$
$$\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0$$

$$\left.\begin{array}{l}\dot{V}_{fa(1)}-z_f\dot{I}_{fa(1)}=\dot{V}_{fa(2)}-z_f\dot{I}_{fa(2)}=\dot{V}_{fa(0)}-(z_f+3z_g)\dot{I}_{fa(0)}\\ \dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0\end{array}\right\}$$

8-1 简单不对称短路的分析——非全属性短路

(3) 两相(b相和c相)非全属性短路接地——复合序网



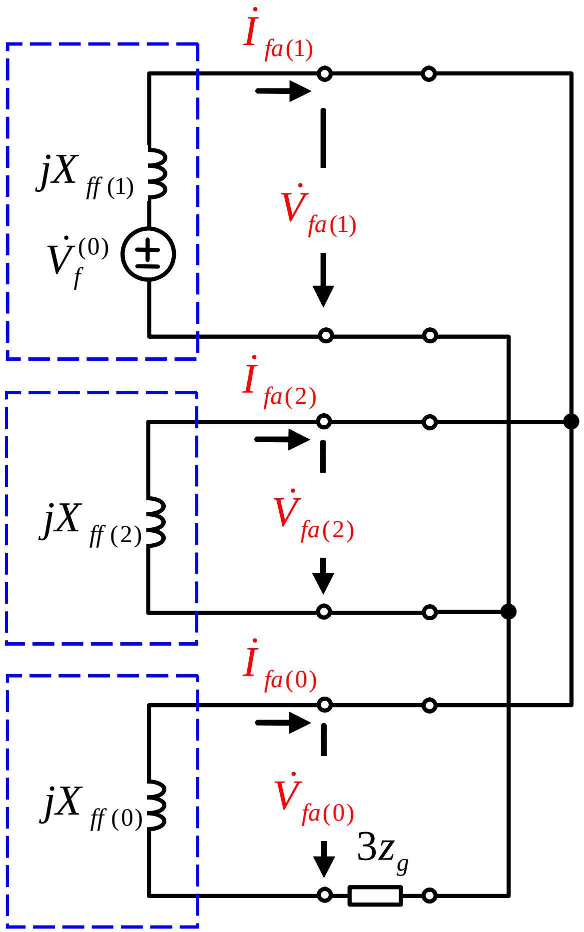


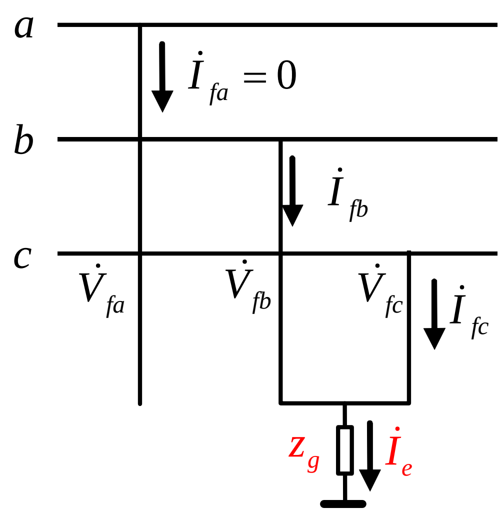
序分量边界条件：

$$\left.\begin{aligned}&\dot{V}_{fa(1)}-z_f\dot{I}_{fa(1)}=\dot{V}_{fa(2)}-z_f\dot{I}_{fa(2)}=\dot{V}_{fa(0)}-(z_f+3z_g)\dot{I}_{fa(0)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0\end{aligned}\right\}$$

8-1 简单不对称短路的分析——非金属性短路

(2) 两相(b相和c相)非金属性短路接地——复合序网



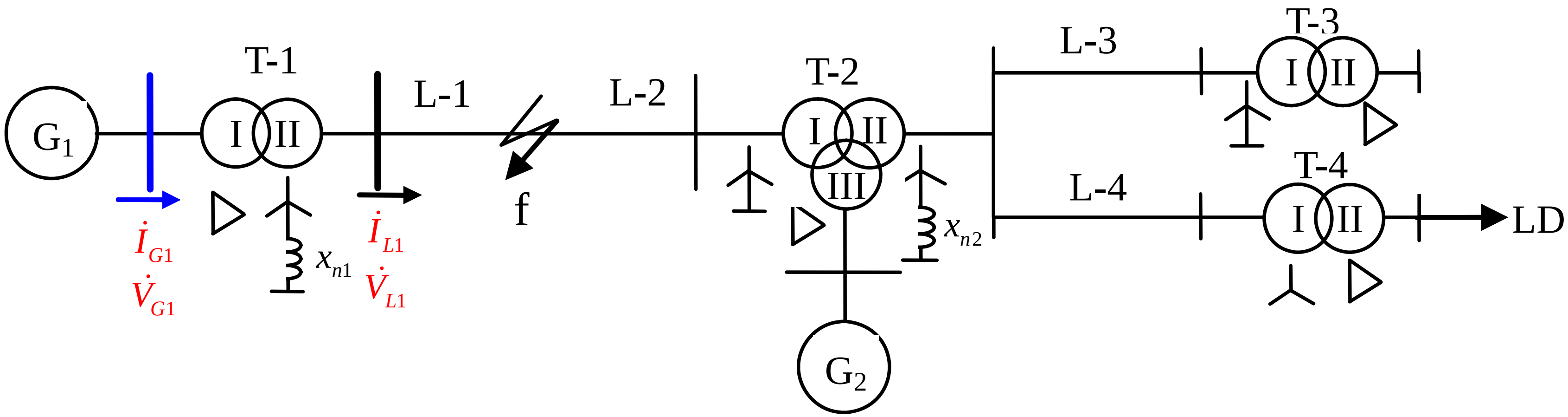


序分量边界条件：

$$\left.\begin{aligned}&\dot{V}_{fa(1)}=\dot{V}_{fa(2)}=\dot{V}_{fa(0)}-3z_g\dot{I}_{fa(0)}\\&\dot{I}_{fa(1)}+\dot{I}_{fa(2)}+\dot{I}_{fa(0)}=0\end{aligned}\right\}$$

8-2 电压和电流对称分量经变压器后的相位变换

1. 不对称故障电压电流分布计算——举例

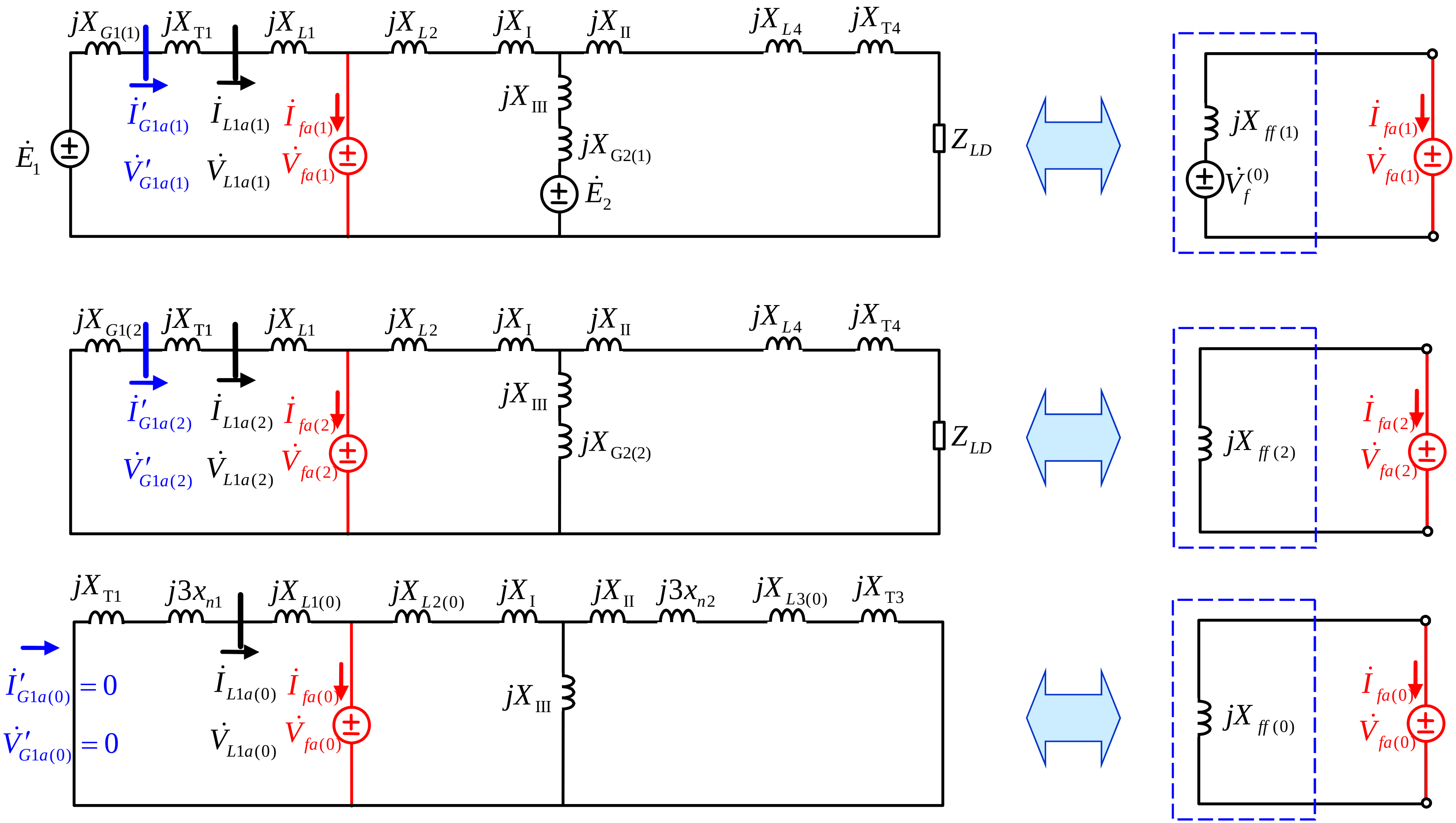


$$\begin{aligned}\dot{V}_{G1A} &= \dot{V}_{G1A(1)} + \dot{V}_{G1A(2)} + \dot{V}_{G1A(0)}\\ \dot{V}_{G1B} &= \dot{V}_{G1B(1)} + \dot{V}_{G1B(2)} + \dot{V}_{G1B(0)}\\ \dot{V}_{G1C} &= \dot{V}_{G1C(1)} + \dot{V}_{G1C(2)} + \dot{V}_{G1C(0)}\end{aligned}$$

$$\begin{aligned}\dot{I}_{G1A} &= \dot{I}_{G1A(1)} + \dot{I}_{G1A(2)} + \dot{I}_{G1A(0)}\\ \dot{I}_{G1B} &= \dot{I}_{G1B(1)} + \dot{I}_{G1B(2)} + \dot{I}_{G1B(0)}\\ \dot{I}_{G1C} &= \dot{I}_{G1C(1)} + \dot{I}_{G1C(2)} + \dot{I}_{G1C(0)}\end{aligned}$$

$$\begin{aligned}\dot{I}_{L1a} &= \dot{I}_{L1a(1)} + \dot{I}_{L1a(2)} + \dot{I}_{L1a(0)}\\ \dot{I}_{L1b} &= \dot{I}_{L1b(1)} + \dot{I}_{L1b(2)} + \dot{I}_{L1b(0)}\\ \dot{I}_{L1c} &= \dot{I}_{L1c(1)} + \dot{I}_{L1c(2)} + \dot{I}_{L1c(0)}\end{aligned}$$

1. 不对称故障电压电流分布计算——举例



1. 不对称故障电压电流分布计算——基本步骤

不对称故障电压电流分布计算

- 由序网方程和序分量边界条件求解故障口电流电压各序分量(复合序网、方程求解等);
- 由各序网络计算电流电压各序分量的分布情况;
- 对某一节点各序电压分量或者支路各序电流分量进行综合即可得到相应的电压和电流相量;
- 必须注意对称分量经过变压器后的相位变换问题。

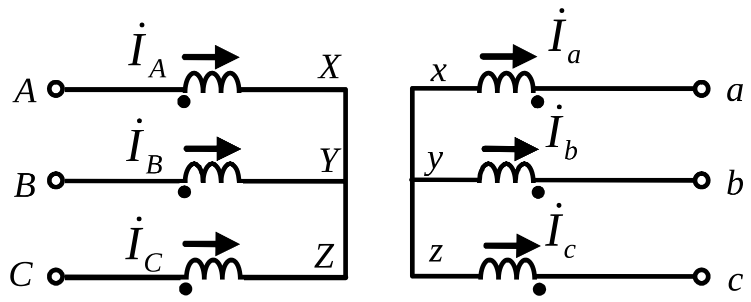
1. 不对称故障电压电流分布计算——基本特点

不对称故障电压电流对称分量分布的特点

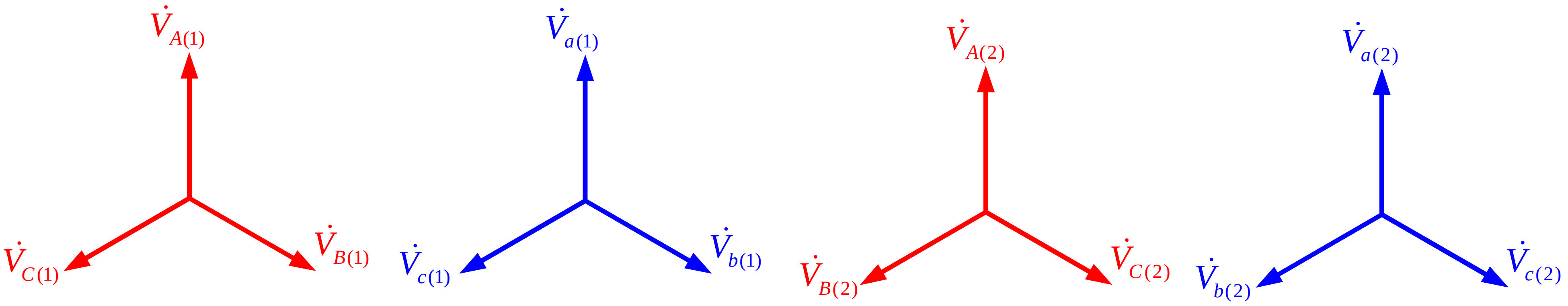
- 电源点负序电压为零；
- 正序电压在电源点最高，短路点最低；
- 故障点零序和负序电压最高；
- 变压器三角侧零序电压为零；
- 网络中各点三相电压不对称程度主要决定于负序分量，负序分量愈大，电压愈不对称。

2. 电压电流对称分量经变压器后的相位变换

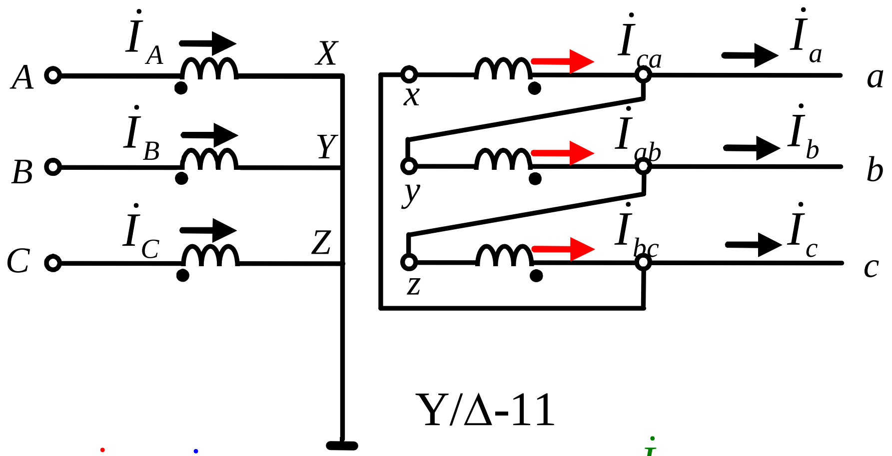
(1)对称分量经变压器后的相位变换

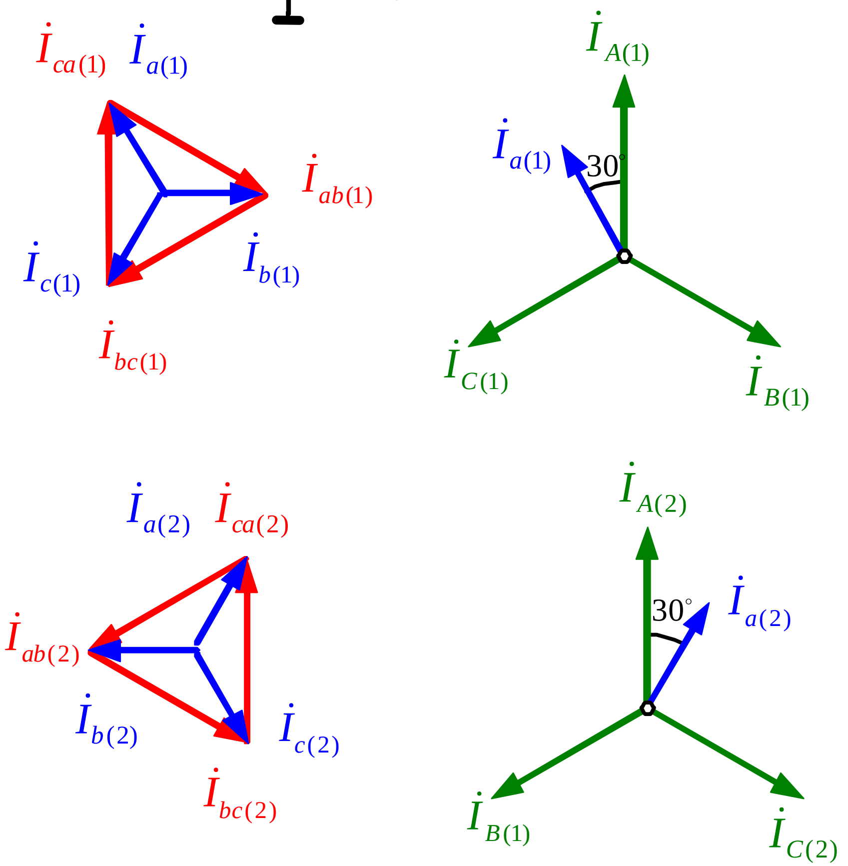


Y/Y-12



(2)对称分量经变压器后的相位变换





$$\dot{I}_{a(1)} = ke^{j30^0}\dot{I}_{A(1)}$$

$$\dot{I}_{a(2)} = ke^{-j30^0}\dot{I}_{A(2)}$$

$$\dot{V}_{a(1)} = \frac{1}{k}e^{j30^0}\dot{V}_{A(1)}$$

$$\dot{V}_{a(2)} = \frac{1}{k}e^{-j30^0}\dot{V}_{A(2)}$$

$$\dot{V}_{ab(1)} = \frac{1}{k}e^{j30^\circ}\dot{V}_{AB(1)}$$

$$\dot{V}_{ab(2)} = \frac{1}{k}e^{-j30^\circ}\dot{V}_{AB(2)}$$

(2)对称分量经变压器后的相位变换——应用举例

Step 1:作各序网络：$X_{ff(1)}=X_{ff(2)}=0.26, X_{ff(0)}=0.48$

Step 2:计算故障口电流正序分量

$$\dot{I}_{fA(1)}=\frac{\dot{V}_f^{(0)}}{j(X_{ff(1)}+X_{ff(2)}+X_{ff(0)})}=\frac{j1.0}{j(0.26+0.26+0.48)}=1.0$$

Step 3:计算故障口电流各序分量

$$\dot{I}_{fA(2)}=\dot{I}_{fA(0)}=\dot{I}_{fA(1)}=1.0,\quad \dot{V}_{fA(1)}=j(X_{ff(2)}+X_{ff(0)})\dot{I}_{fA(1)}=j0.74$$

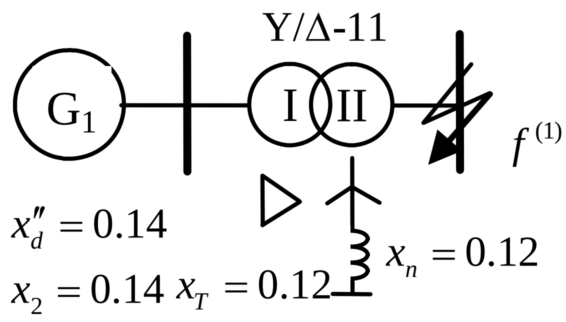
Step 4:计算发电机端电流各序分量

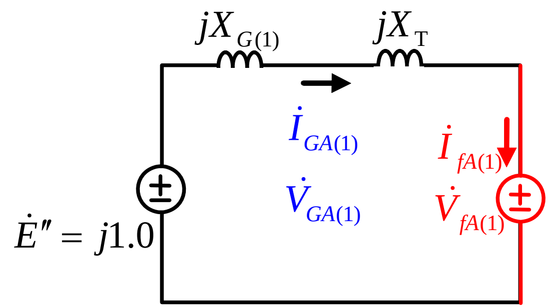
$$\dot{I}_{Ga(1)}=\dot{I}_{GA(1)}e^{j30^\circ}=\dot{I}_{fA(1)}e^{j30^\circ}=e^{j30^\circ}$$

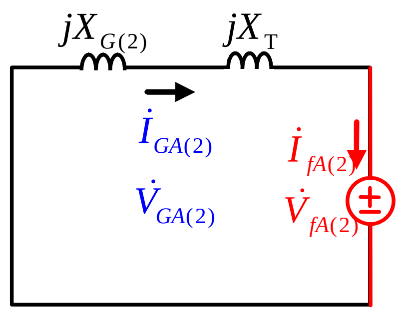
$$\dot{I}_{Ga(2)}=\dot{I}_{GA(2)}e^{-j30^\circ}=\dot{I}_{fA(1)}e^{-j30^\circ}=e^{-j30^\circ}$$

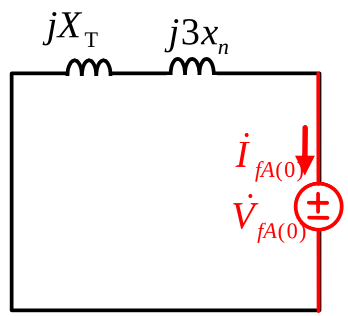
$$\dot{I}_{Ga(0)}=0$$

计算发电机各相电流









(2)对称分量经变压器后的相位变换——应用举例

Step 5:计算发电机端各相电流

$$\dot{I}_{Ga}=\dot{I}_{Ga(1)}+\dot{I}_{Ga(2)}+\dot{I}_{Ga(0)}=e^{j30^\circ}+e^{-j30^\circ}=\sqrt{3}$$

$$\dot{I}_{Gb}=\alpha^2\dot{I}_{Ga(1)}+\alpha\dot{I}_{Ga(2)}+\dot{I}_{Ga(0)}=e^{-j90^\circ}+e^{j90^\circ}=0$$

$$\dot{I}_{Gc}=\alpha\dot{I}_{Ga(1)}+\alpha^2\dot{I}_{Ga(2)}+\dot{I}_{Ga(0)}=e^{j150^\circ}+e^{-j150^\circ}=-\sqrt{3}$$

Step 6:计算故障口电压各序分量

$$\dot{V}_{fA(1)}=j(X_{ff(2)}+X_{ff(0)})\dot{I}_{fA(1)}=j0.74$$

$$\dot{V}_{fA(2)}=-jX_{ff(2)}\dot{I}_{fA(1)}=-j0.26,\quad \dot{V}_{fA(0)}=-jX_{ff(0)}\dot{I}_{fA(1)}=-j0.48$$

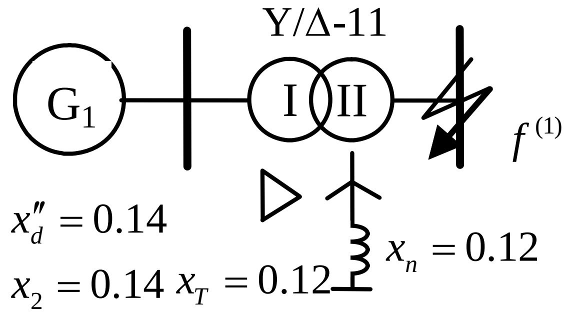
Step 7:计算发电机端电压各序分量

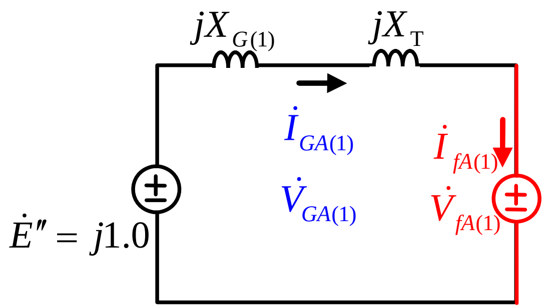
$$\dot{V}_{GA(1)}=\dot{V}_{fA(1)}+jX_T\dot{I}_{fA(1)}=j0.74+j0.12=j0.86$$

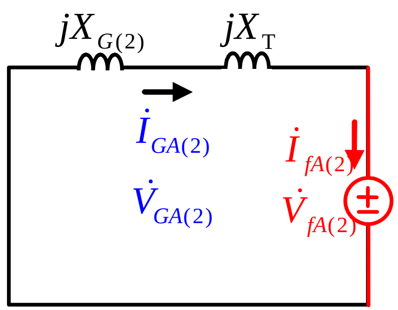
$$\dot{V}_{GA(2)}=\dot{V}_{fA(2)}+jX_T\dot{I}_{fA(2)}=-j0.26+j0.12=-j0.14$$

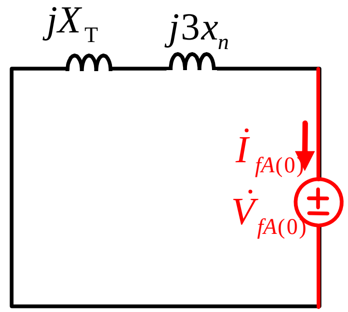
$$\dot{V}_{GA(0)}=0$$

计算发电机各相电流









(2)对称分量经变压器后的相位变换——应用举例

Step 7:计算发电机端电压各序分量

$$\dot{V}_{GA(1)}=\dot{V}_{fA(1)}+jX_T\dot{I}_{fA(1)}=j0.74+j0.12=j0.86$$

$$\dot{V}_{GA(2)}=\dot{V}_{fA(2)}+jX_T\dot{I}_{fA(2)}=-j0.26+j0.12=-j0.14$$

$$\dot{V}_{GA(0)}=0$$

$$\dot{V}_{Ga(1)}=\dot{V}_{GA(1)}e^{j30^\circ},\dot{V}_{Ga(2)}=\dot{V}_{GA(2)}e^{-j30^\circ},\dot{V}_{Ga(0)}=0$$

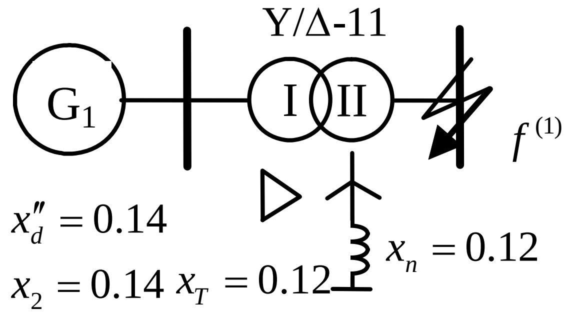
Step 8:计算发电机端各相电压

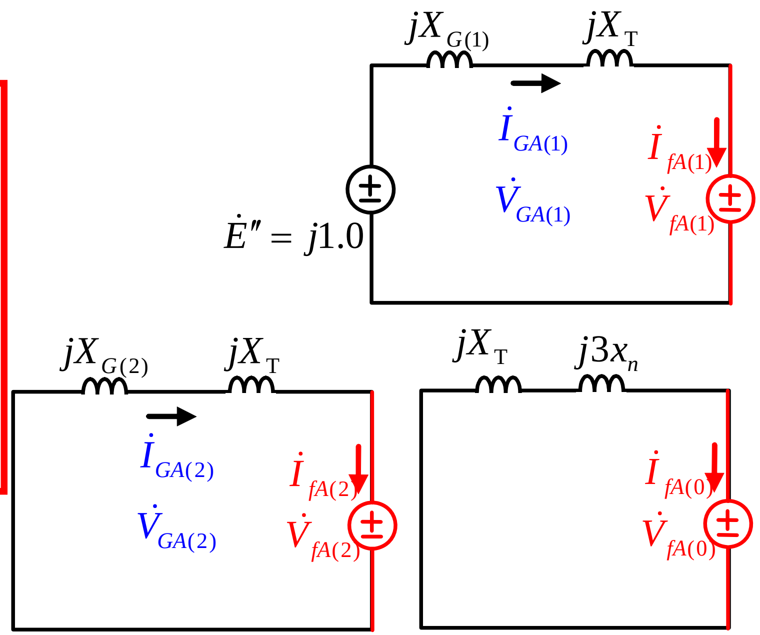
$$\dot{V}_{Ga}=\dot{V}_{Ga(1)}+\dot{V}_{Ga(2)}+\dot{V}_{Ga(0)}=\dot{V}_{GA(1)}e^{j30^\circ}+\dot{V}_{GA(2)}e^{-j30^\circ}$$

$$\dot{V}_{Gb}=\alpha^2\dot{V}_{Ga(1)}+\alpha\dot{V}_{Ga(2)}+\dot{V}_{Ga(0)}=\dot{V}_{GA(1)}e^{-j90^\circ}+\dot{V}_{GA(2)}e^{j90^\circ}$$

$$\dot{V}_{Gc}=\alpha\dot{V}_{Ga(1)}+\alpha^2\dot{V}_{Ga(2)}+\dot{V}_{Ga(0)}=\dot{V}_{GA(1)}e^{j150^\circ}+\dot{V}_{GA(2)}e^{-j150^\circ}$$

计算发电机各相电流

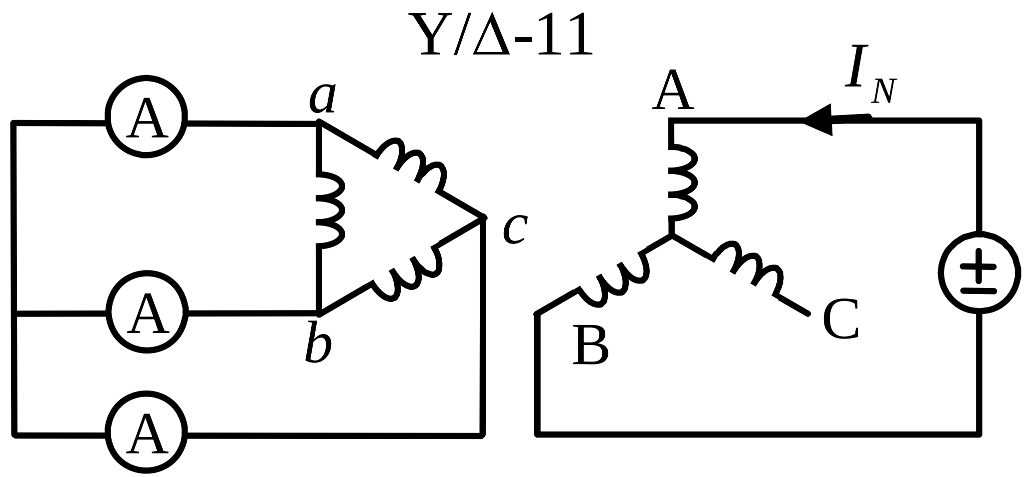




(2)对称分量经变压器后的相位变换——应用举例

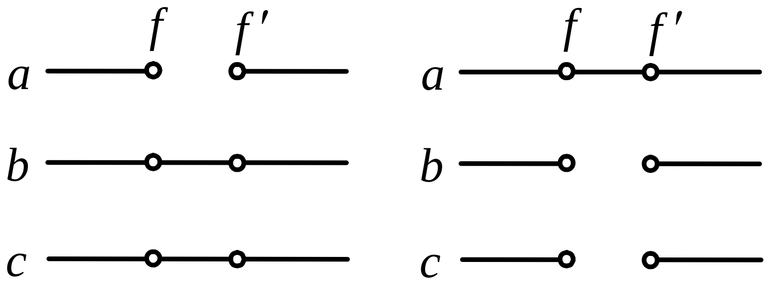
思考题：

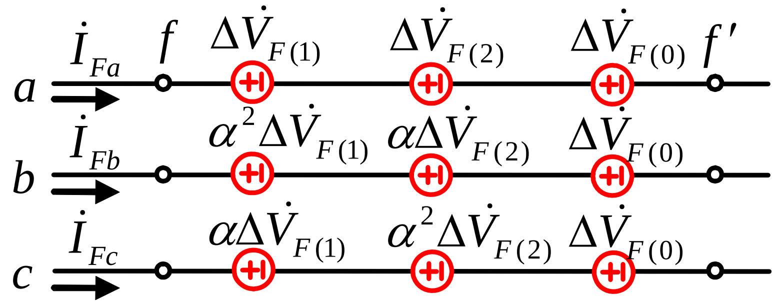
变压器绕组联结组别为$Y/\Delta-11$，Y侧AB相间施加电压至产生额定电流，试问：Δ侧各电流表读数应为多少？



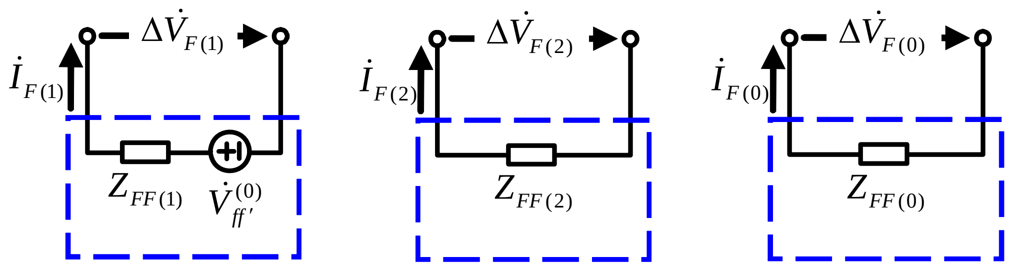
8-3 非全相断线的分析计算

1. 对称分量法分析非全相断线——序网方程





$$\left.\begin{aligned}\Delta\dot{V}_{F(1)} &= \dot{V}_{ff'}^{(0)} - Z_{FF(1)}\dot{I}_{F(1)}\\ \Delta\dot{V}_{F(2)} &= \quad\quad\;\; - Z_{FF(2)}\dot{I}_{F(2)}\\ \Delta\dot{V}_{F(0)} &= \quad\quad\;\; - Z_{FF(0)}\dot{I}_{F(0)}\end{aligned}\right\}(8-24)$$

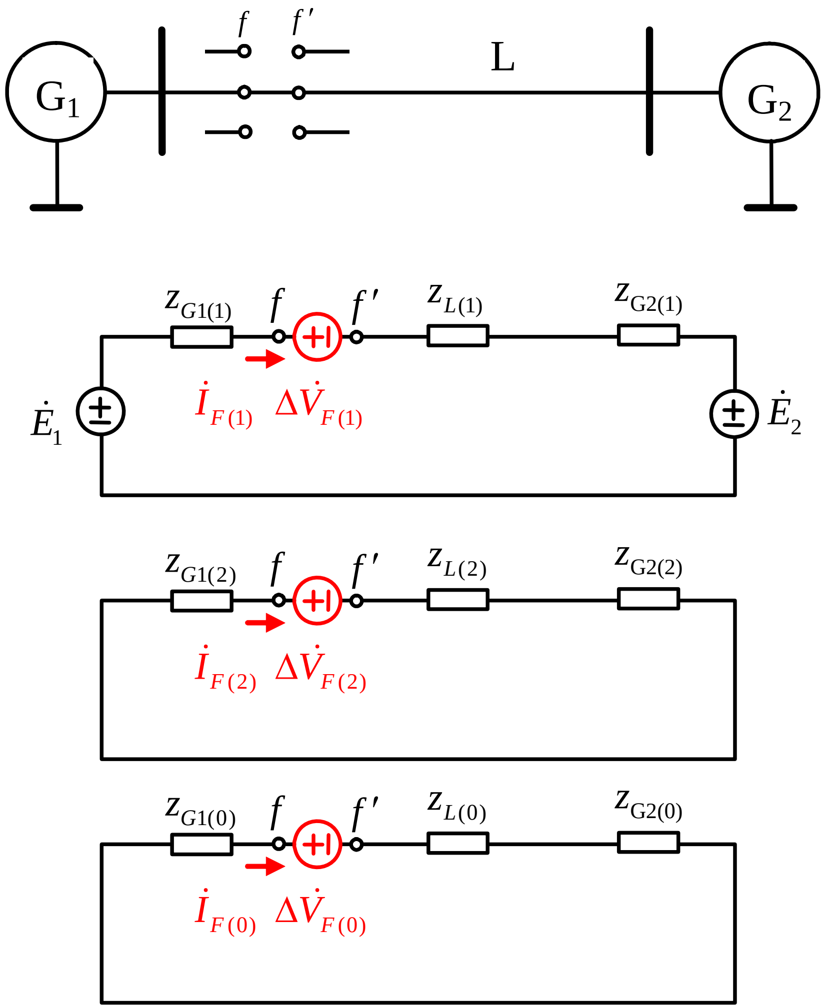


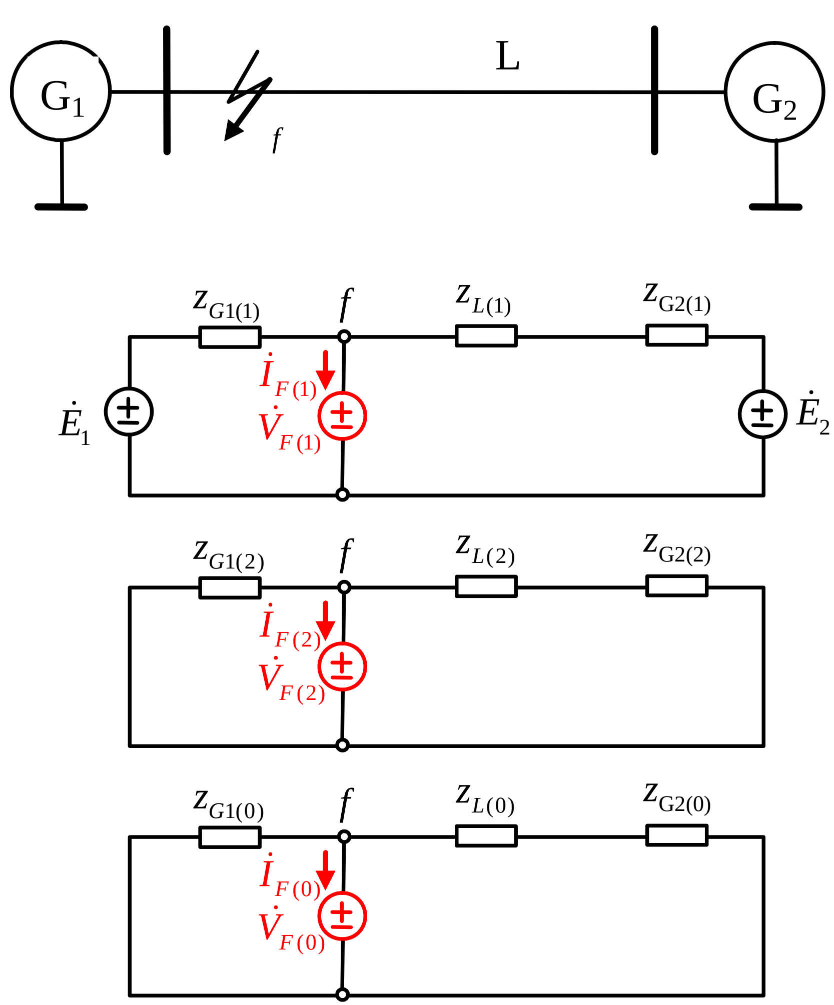
$\dot{V}_{ff'}^{(0)}$:故障口ff'的开路电压,即当ff'两点间三相断开时,网络内电势源在端口ff'产生的电压

$Z_{FF(1)}$、$Z_{FF(2)}$、$Z_{FF(0)}$:故障口ff'的各序输入阻抗

8-3 非全相断线的分析计算

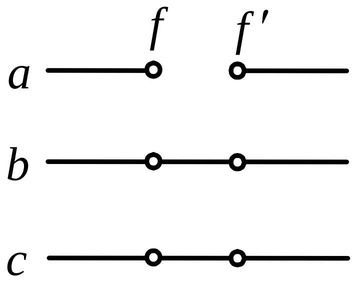
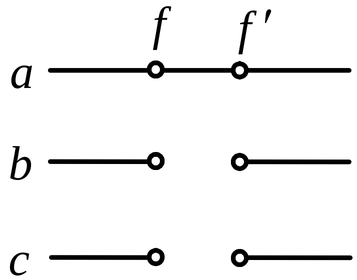
2. 非全相断线与不对称短路的区别





8-3 非全相断线的分析计算

3. 非全相断线的故障边界条件

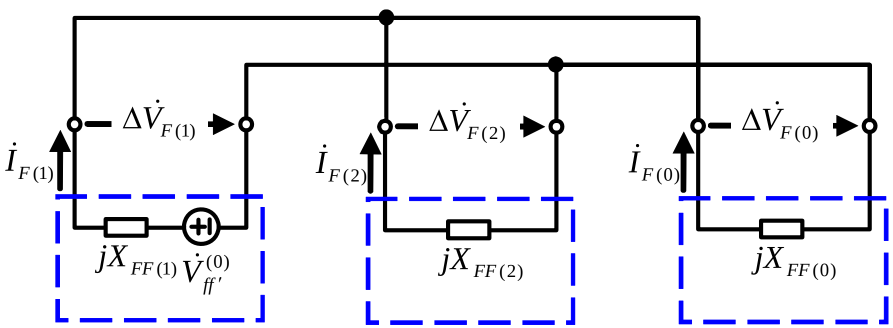
单相(a相)断线	两相(b相和c相)断开
	
$\Delta\dot{V}_{Fb}=\Delta\dot{V}_{Fc}=0,\ \dot{I}_{Fa}=0$	$\Delta\dot{V}_{Fa}=0,\ \ \dot{I}_{Fb}=\dot{I}_{Fc}=0$
$\left.\begin{array}{l}\Delta\dot{V}_{F(1)}=\Delta\dot{V}_{F(2)}=\Delta\dot{V}_{F(0)}\\ \dot{I}_{F(1)}+\dot{I}_{F(2)}+\dot{I}_{F(0)}=0\end{array}\right\}$	$\left.\begin{array}{l}\Delta\dot{V}_{F(1)}+\Delta\dot{V}_{F(2)}+\Delta\dot{V}_{F(0)}=0\\ \dot{I}_{F(1)}=\dot{I}_{F(2)}=\dot{I}_{F(0)}\end{array}\right\}$

8-3 非全相断线的分析计算

3. 非全相断线的复合序网

单相(*a*相)断线

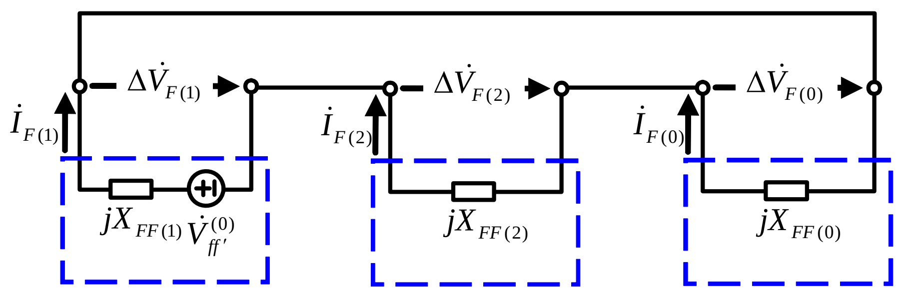
$$\left.\begin{aligned}&\Delta\dot V_{F(1)}=\Delta\dot V_{F(2)}=\Delta\dot V_{F(0)}\\&\dot I_{F(1)}+\dot I_{F(2)}+\dot I_{F(0)}=0\end{aligned}\right\}$$



$$\dot I_{F(1)}=\frac{\dot V_{ff'}^{(0)}}{j(X_{FF(1)}+X_{FF(2)}//X_{FF(0)})}$$

两相(*b*相和*c*相)断开

$$\left.\begin{aligned}&\Delta\dot V_{F(1)}+\Delta\dot V_{F(2)}+\Delta\dot V_{F(0)}=0\\&\dot I_{F(1)}=\dot I_{F(2)}=\dot I_{F(0)}\end{aligned}\right\}$$



$$\dot I_{F(1)}=\frac{\dot V_{ff'}^{(0)}}{j(X_{FF(1)}+X_{FF(2)}+X_{FF(0)})}$$

8-3 非全相断线的分析计算

4. 非全相断线的故障口电压电流各序分量

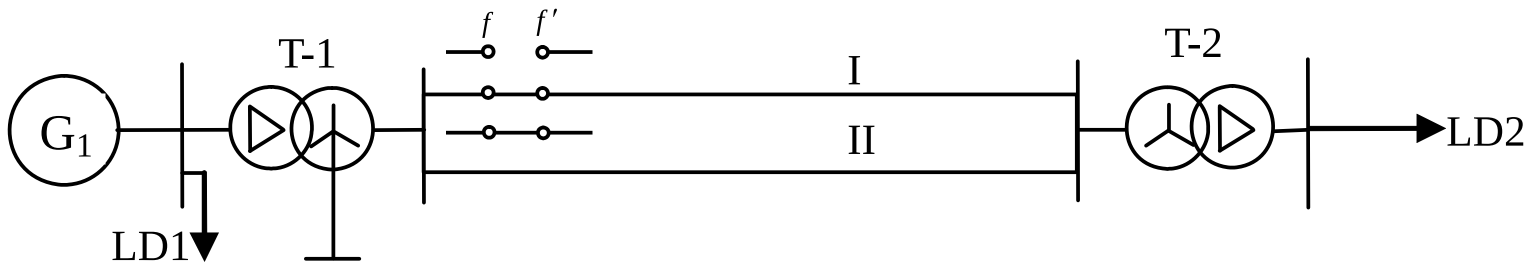
单相(a相)断线	两相(b相和c相)断开
$\left.\begin{array}{l}\Delta\dot{V}_{F(1)}=\Delta\dot{V}_{F(2)}=\Delta\dot{V}_{F(0)}\\ \dot{I}_{F(1)}+\dot{I}_{F(2)}+\dot{I}_{F(0)}=0\end{array}\right\}$	$\left.\begin{array}{l}\Delta\dot{V}_{F(1)}+\Delta\dot{V}_{F(2)}+\Delta\dot{V}_{F(0)}=0\\ \dot{I}_{F(1)}=\dot{I}_{F(2)}=\dot{I}_{F(0)}\end{array}\right\}$
$\dot{I}_{F(1)}=\dfrac{\dot{V}_{ff'}^{(0)}}{j(X_{FF(1)}+X_{FF(2)}//X_{FF(0)})}$	$\dot{I}_{F(1)}=\dfrac{\dot{V}_{ff'}^{(0)}}{j(X_{FF(1)}+X_{FF(2)}+X_{FF(0)})}$
$\dot{I}_{F(2)}=-\dfrac{X_{FF(0)}}{X_{FF(2)}+X_{FF(0)}}\dot{I}_{F(1)}$	$\Delta\dot{V}_{F(1)}=j(X_{FF(2)}+X_{FF(0)})\dot{I}_{F(1)}$ $\Delta\dot{V}_{F(2)}=-jX_{FF(2)}\dot{I}_{F(1)}$ $\Delta\dot{V}_{F(0)}=-jX_{FF(0)}\dot{I}_{F(1)}$
$\dot{I}_{F(0)}=-\dfrac{X_{FF(2)}}{X_{FF(2)}+X_{FF(0)}}\dot{I}_{F(1)}$	

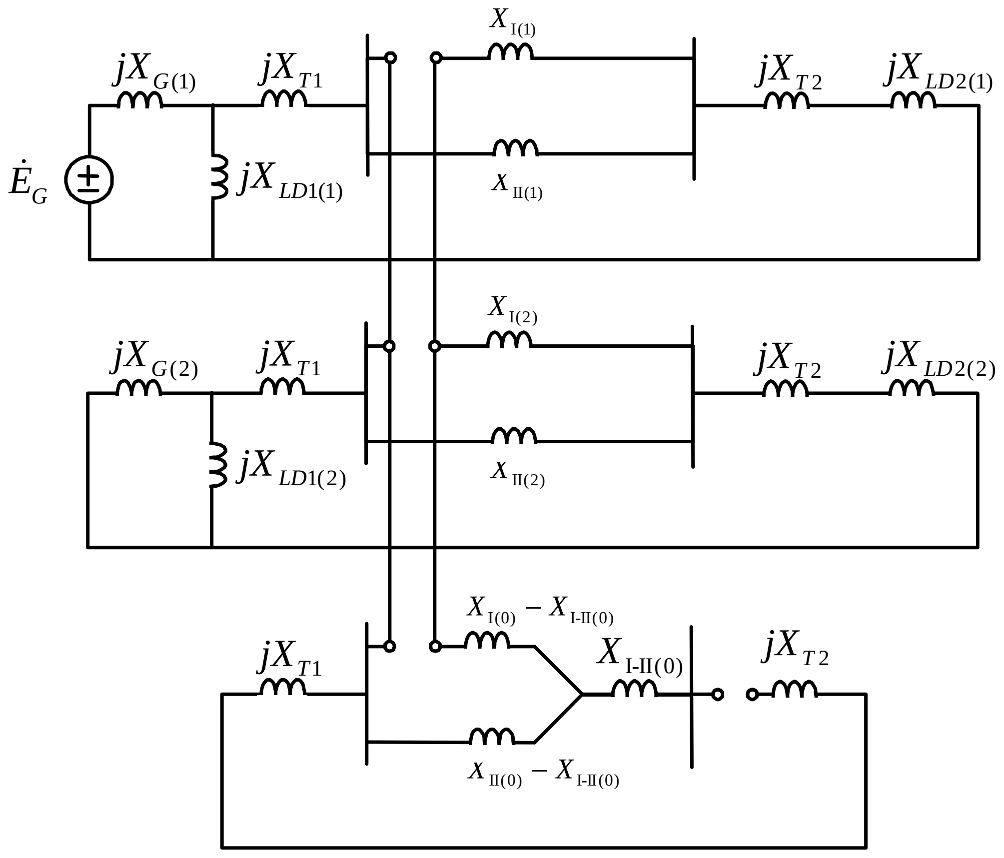
8-3 非全相断线的分析计算

5. 非全相断线的故障口电压电流相量

单相(a相)断线	两相(b相和c相)断开
$\dot{I}_{F(1)}=\dfrac{\dot{V}_{ff'}^{(0)}}{j(X_{FF(1)}+X_{FF(2)}//X_{FF(0)})}$	$\dot{I}_{F(1)}=\dfrac{\dot{V}_{ff'}^{(0)}}{j(X_{FF(1)}+X_{FF(2)}+X_{FF(0)})}$
$\dot{I}_{Fb}=\left(\alpha^{2}-\dfrac{X_{FF(2)}+\alpha X_{FF(0)}}{X_{FF(2)}+X_{FF(0)}}\right)\dot{I}_{F(1)}$	$\dot{I}_{F}=\dfrac{3\dot{V}_{ff'}^{(0)}}{j(X_{FF(1)}+X_{FF(2)}+X_{FF(0)})}$
$\dot{I}_{Fc}=\left(\alpha-\dfrac{X_{FF(2)}+\alpha^{2}X_{FF(0)}}{X_{FF(2)}+X_{FF(0)}}\right)\dot{I}_{F(1)}$	$\Delta\dot{V}_{Fb}=j\left[(\alpha^{2}-\alpha)X_{FF(2)}+(\alpha^{2}-1)X_{FF(0)}\right]\dot{I}_{F(1)}$
$\Delta\dot{V}_{F}=3\Delta\dot{V}_{F(1)}=j\dfrac{3X_{FF(2)}X_{FF(0)}}{X_{FF(2)}+X_{FF(0)}}\dot{I}_{F(1)}$	$\Delta\dot{V}_{Fc}=j\left[(\alpha-\alpha^{2})X_{FF(2)}+(\alpha-1)X_{FF(0)}\right]\dot{I}_{F(1)}$

8-3 非全相断线的分析计算——举例





8-3 非全相断线的分析计算——举例