

# 第七章 电力系统各元件的序阻抗和等值电路

7-1 对称分量法在不对称短路计算中的应用

7-2 同步发电机的负序和零序电抗

7-3 变压器的零序等值电路及其参数

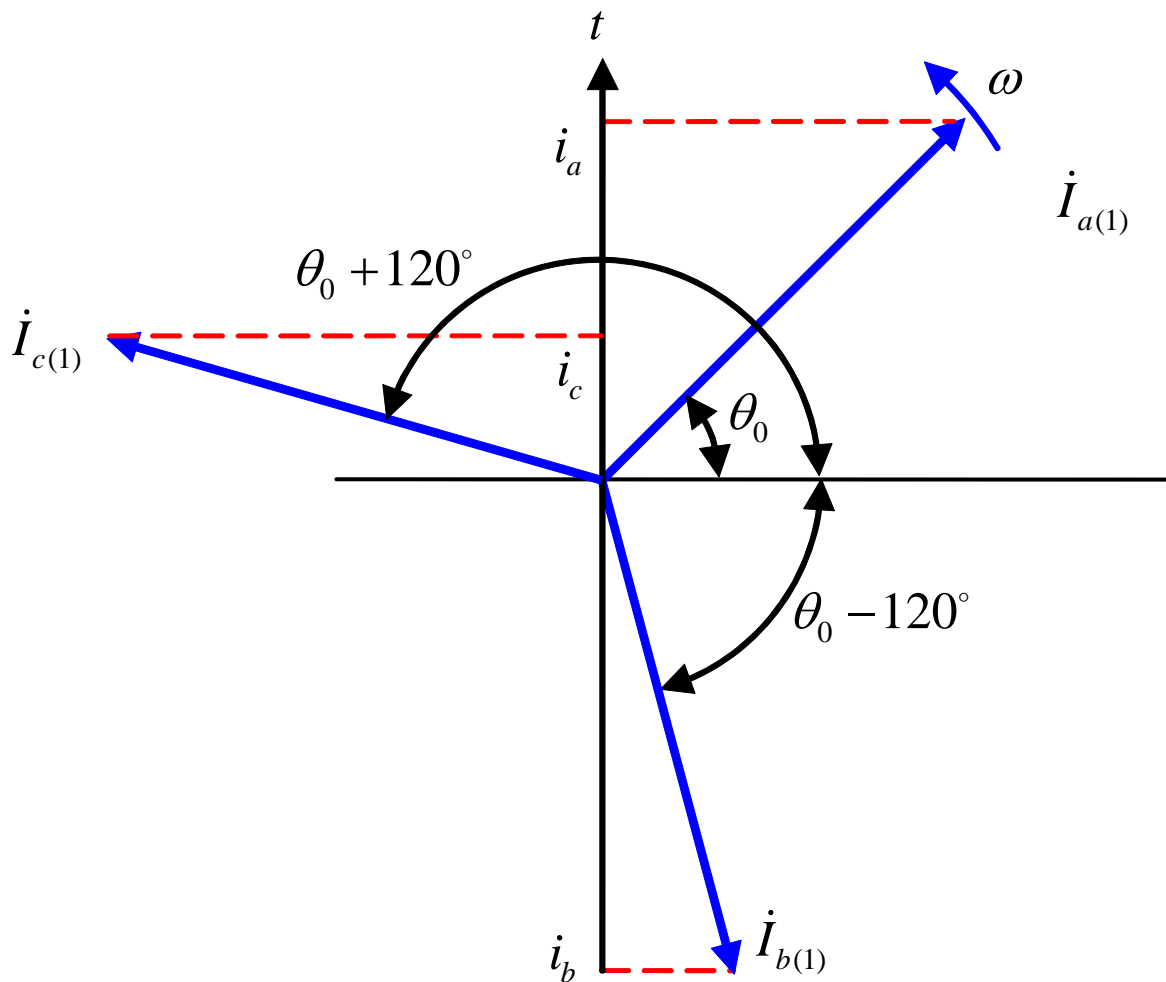
7-4 架空输电线路的零序阻抗及其等值电路

7-6 综合负荷的序阻抗

7-7 电力系统各序网络的制定

# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量



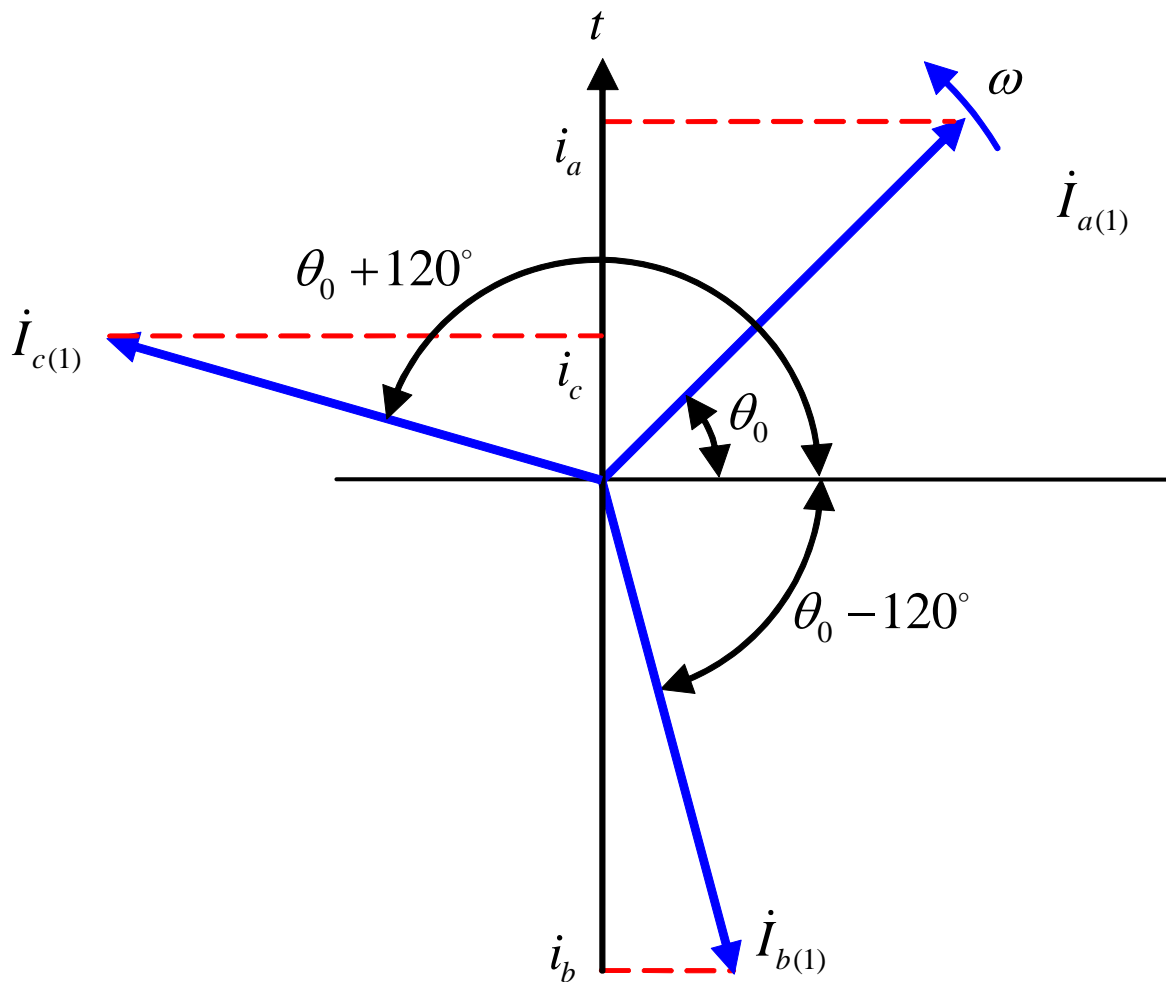
$$i_a = I_m \sin(\omega t + \theta_0)$$

$$i_b = I_m \sin(\omega t + \theta_0 - 120^\circ)$$

$$i_c = I_m \sin(\omega t + \theta_0 + 120^\circ)$$

# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量



$$i_a = I_m \sin(\omega t + \theta_0)$$

$$i_b = I_m \sin(\omega t + \theta_0 - 120^\circ)$$

$$i_c = I_m \sin(\omega t + \theta_0 + 120^\circ)$$

正序分量:

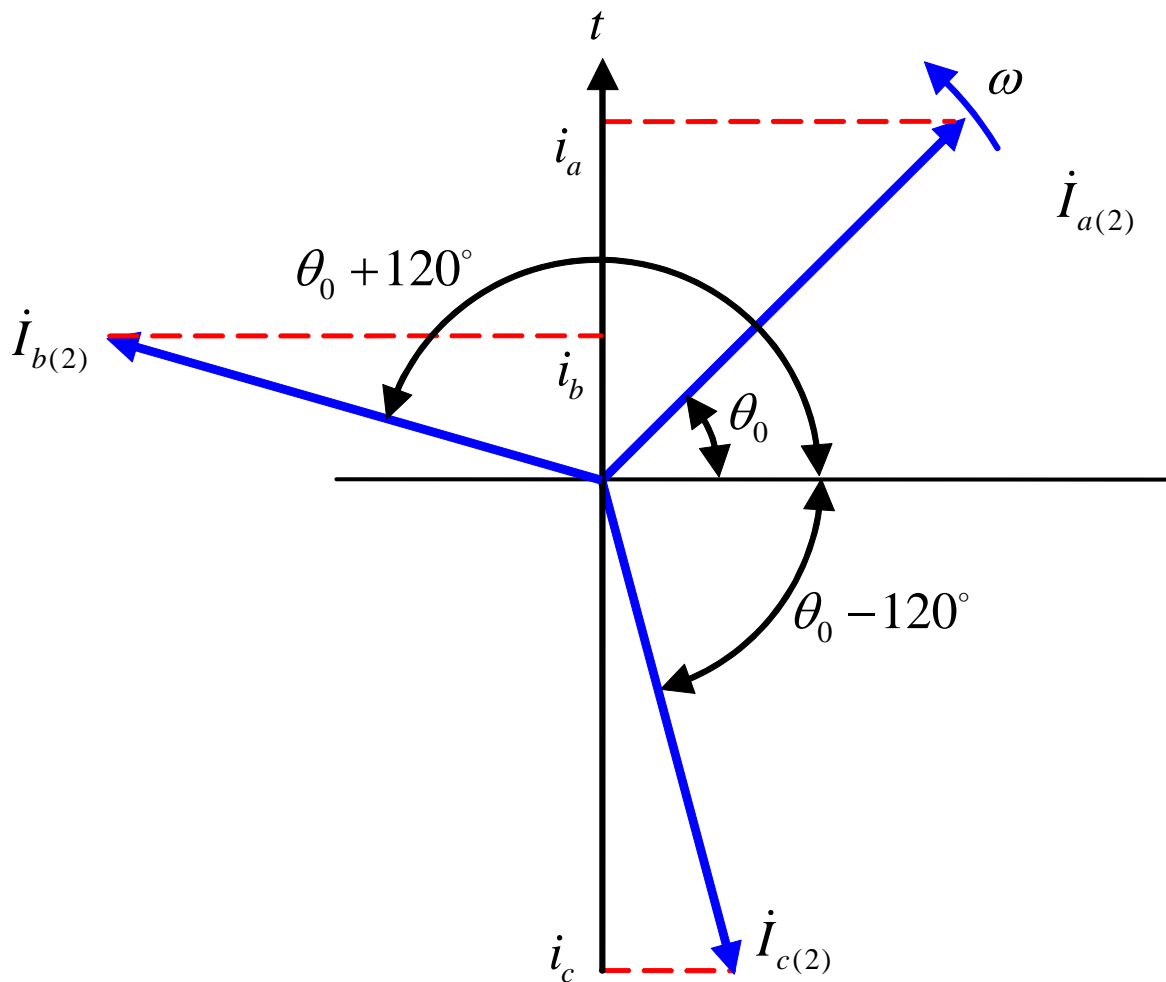
$$\dot{I}_{b(1)} = \alpha^2 \dot{I}_{a(1)} = e^{-j120^\circ} \dot{I}_{a(1)}$$

$$\dot{I}_{c(1)} = \alpha \dot{I}_{a(1)} = e^{j120^\circ} \dot{I}_{a(1)}$$

$$\alpha = e^{j120^\circ}, \quad 1 + \alpha + \alpha^2 = 0$$

# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量



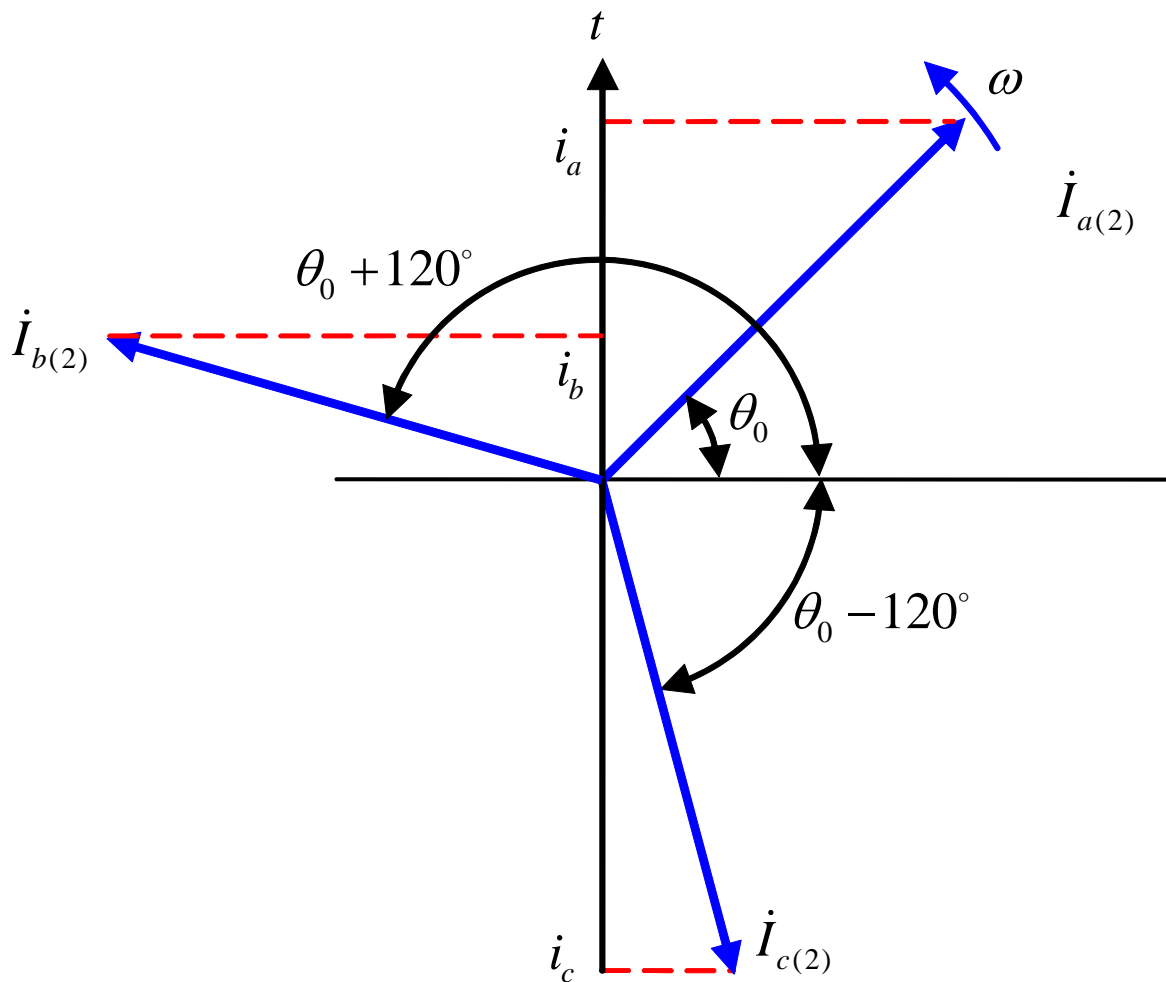
$$i_a = I_m \sin(\omega t + \theta_0)$$

$$i_b = I_m \sin(\omega t + \theta_0 + 120^\circ)$$

$$i_c = I_m \sin(\omega t + \theta_0 - 120^\circ)$$

# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量



$$i_a = I_m \sin(\omega t + \theta_0)$$

$$i_b = I_m \sin(\omega t + \theta_0 + 120^\circ)$$

$$i_c = I_m \sin(\omega t + \theta_0 - 120^\circ)$$

负序分量:

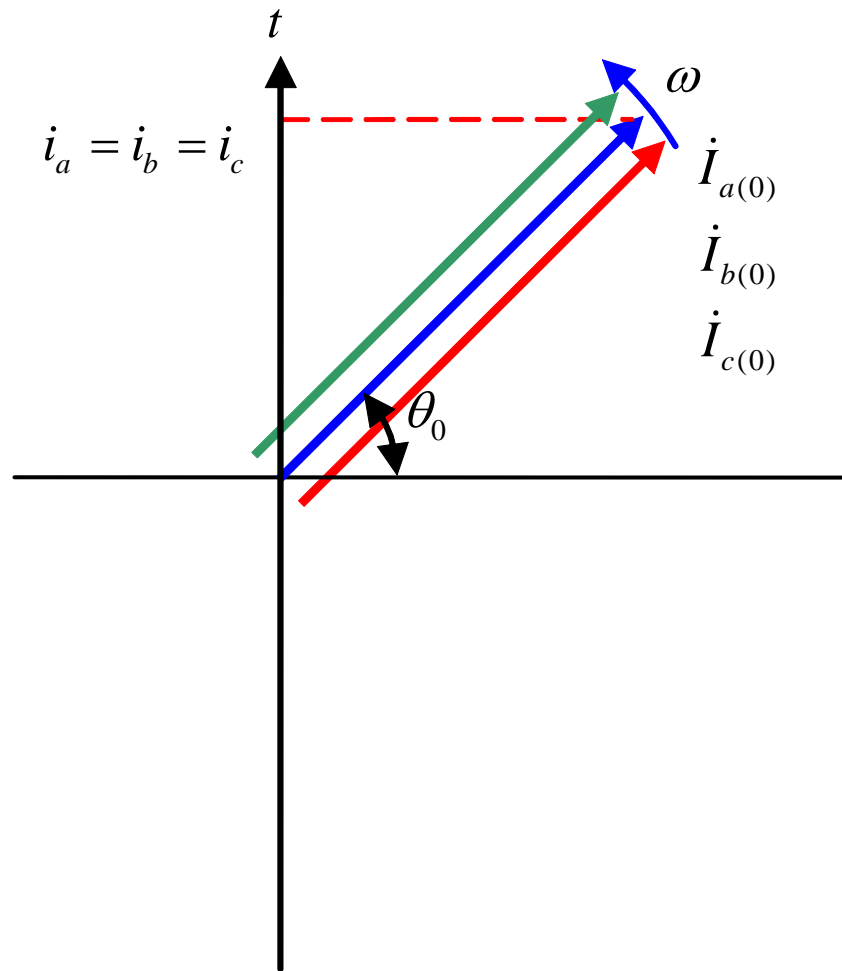
$$\dot{I}_{b(2)} = \alpha \dot{I}_{a(2)} = e^{j120^\circ} \dot{I}_{a(2)}$$

$$\dot{I}_{c(2)} = \alpha^2 \dot{I}_{a(2)} = e^{-j120^\circ} \dot{I}_{a(2)}$$

$$\alpha = e^{j120^\circ}, 1 + \alpha + \alpha^2 = 0$$

# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量



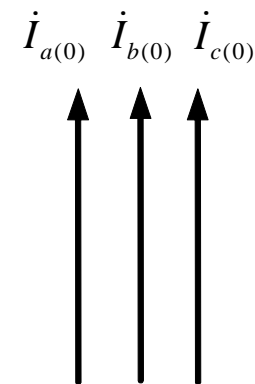
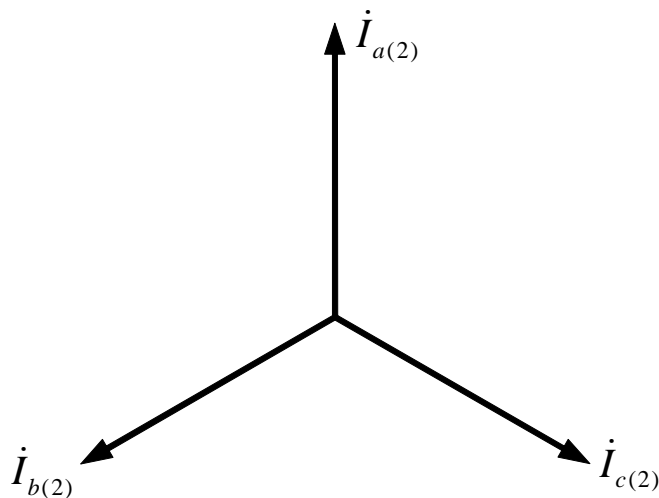
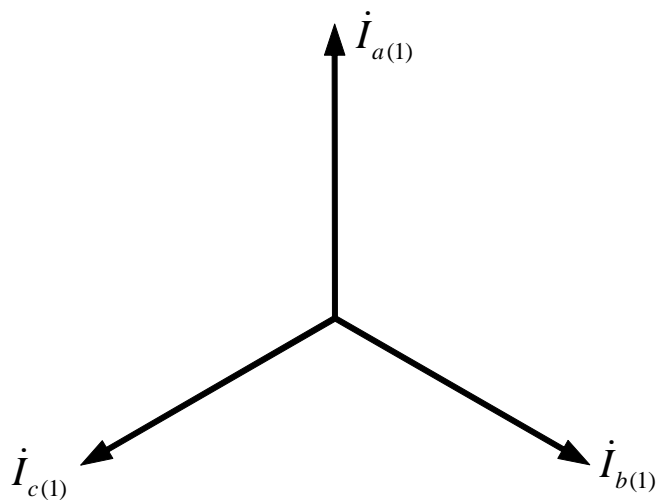
$$\begin{aligned}i_a &= I_m \sin(\omega t + \theta_0) \\i_b &= I_m \sin(\omega t + \theta_0) \\i_c &= I_m \sin(\omega t + \theta_0)\end{aligned}$$

零序分量:

$$\dot{I}_{a(0)} = \dot{I}_{b(0)} = \dot{I}_{c(0)}$$

# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量



正序分量:

$$\dot{I}_{b(1)} = \alpha^2 \dot{I}_{a(1)} = e^{-j120^\circ} \dot{I}_{a(1)}$$

$$\dot{I}_{c(1)} = \alpha \dot{I}_{a(1)} = e^{j120^\circ} \dot{I}_{a(1)}$$

负序分量:

$$\dot{I}_{b(2)} = \alpha \dot{I}_{a(2)} = e^{j120^\circ} \dot{I}_{a(2)}$$

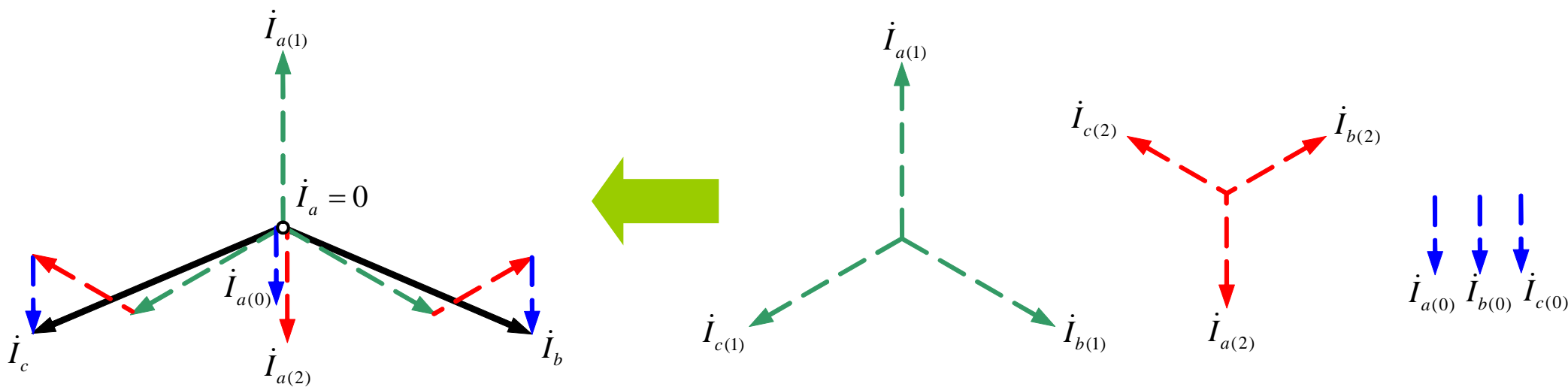
$$\dot{I}_{c(2)} = \alpha^2 \dot{I}_{a(2)} = e^{-j120^\circ} \dot{I}_{a(2)}$$

零序分量:

$$\dot{I}_{a(0)} = \dot{I}_{b(0)} = \dot{I}_{c(0)}$$

# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量分解



$$\begin{aligned} \dot{I}_a &= \dot{I}_{a(1)} + \dot{I}_{a(2)} + \dot{I}_{a(0)} \\ \dot{I}_b &= \dot{I}_{b(1)} + \dot{I}_{b(2)} + \dot{I}_{b(0)} \\ \dot{I}_c &= \dot{I}_{c(1)} + \dot{I}_{c(2)} + \dot{I}_{c(0)} \end{aligned}$$

以a相为基准相

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



# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量分解

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

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

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

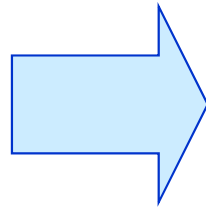
# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量分解

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

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

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



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

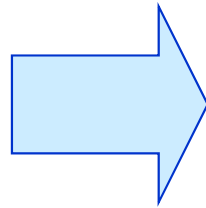
# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量分解

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

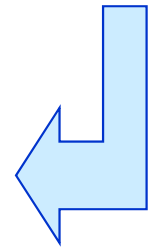
$$\dot{I}_b = \alpha^2 \dot{I}_{a(1)} + \alpha \dot{I}_{a(2)} + \dot{I}_{a(0)}$$

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



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

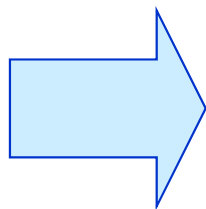
$$\dot{\mathbf{I}}_{abc} = \mathbf{S}^{-1} \dot{\mathbf{I}}_{120}$$



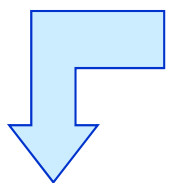
# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量分解

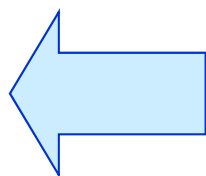
$$\begin{aligned} \dot{I}_a &= \dot{I}_{a(1)} + \dot{I}_{a(2)} + \dot{I}_{a(0)} \\ \dot{I}_b &= \alpha^2 \dot{I}_{a(1)} + \alpha \dot{I}_{a(2)} + \dot{I}_{a(0)} \\ \dot{I}_c &= \alpha \dot{I}_{a(1)} + \alpha^2 \dot{I}_{a(2)} + \dot{I}_{a(0)} \end{aligned}$$



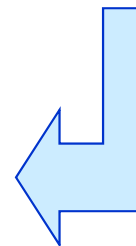
$$\begin{bmatrix} \dot{I}_a \\ \dot{I}_b \\ \dot{I}_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix}$$



$$\dot{\mathbf{I}}_{120} = \mathbf{S} \dot{\mathbf{I}}_{abc}$$



$$\dot{\mathbf{I}}_{abc} = \mathbf{S}^{-1} \dot{\mathbf{I}}_{120}$$

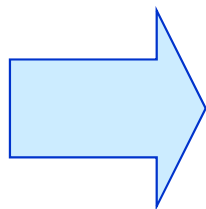


$$\begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \\ 1 & 1 & 1 \end{bmatrix} \begin{bmatrix} \dot{I}_a \\ \dot{I}_b \\ \dot{I}_c \end{bmatrix}$$

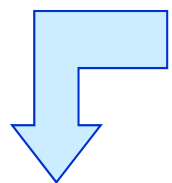
# 7-1 对称分量法在不对称短路计算中的应用

## 1. 不对称三相量的分解——对称分量分解

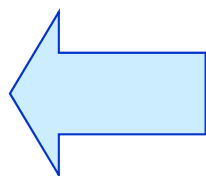
$$\begin{aligned} \dot{I}_a &= \dot{I}_{a(1)} + \dot{I}_{a(2)} + \dot{I}_{a(0)} \\ \dot{I}_b &= \alpha^2 \dot{I}_{a(1)} + \alpha \dot{I}_{a(2)} + \dot{I}_{a(0)} \\ \dot{I}_c &= \alpha \dot{I}_{a(1)} + \alpha^2 \dot{I}_{a(2)} + \dot{I}_{a(0)} \end{aligned}$$



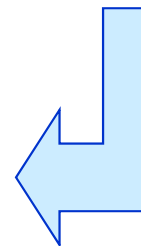
$$\begin{bmatrix} \dot{I}_a \\ \dot{I}_b \\ \dot{I}_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ \alpha^2 & \alpha & 1 \\ \alpha & \alpha^2 & 1 \end{bmatrix} \begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix}$$



$$\dot{\mathbf{I}}_{120} = \mathbf{S} \dot{\mathbf{I}}_{abc}$$

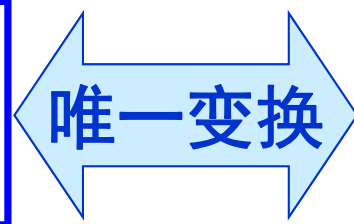


$$\dot{\mathbf{I}}_{abc} = \mathbf{S}^{-1} \dot{\mathbf{I}}_{120}$$



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

$$\dot{\mathbf{I}}_{abc}$$

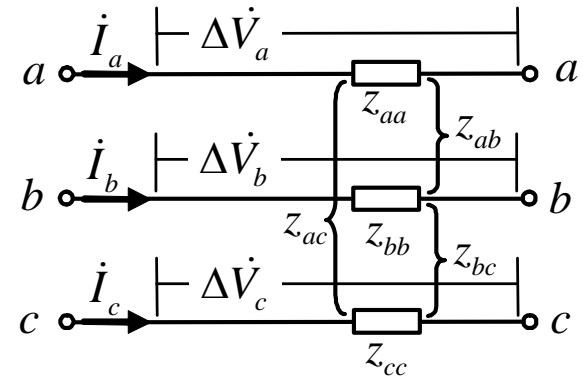
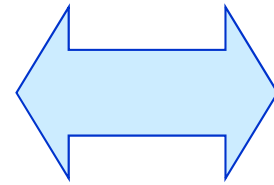


$$\dot{\mathbf{I}}_{120}$$

# 7-1 对称分量法在不对称短路计算中的应用

## 2. 序阻抗的概念——三相对称电路

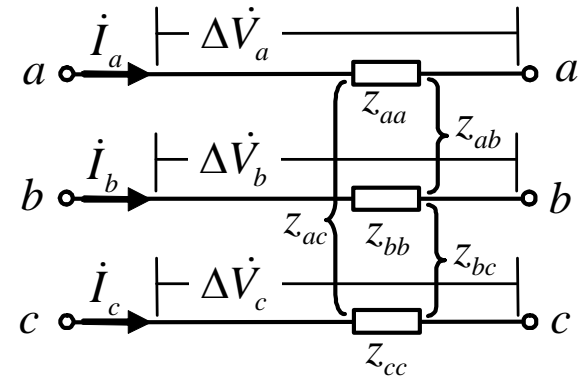
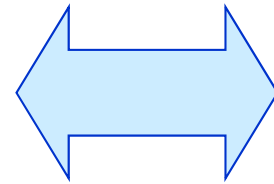
$$\begin{bmatrix} \Delta \dot{V}_a \\ \Delta \dot{V}_b \\ \Delta \dot{V}_c \end{bmatrix} = \begin{bmatrix} z_{aa} & z_{ab} & z_{ca} \\ z_{ab} & z_{bb} & z_{bc} \\ z_{ca} & z_{bc} & z_{cc} \end{bmatrix} \begin{bmatrix} \dot{I}_a \\ \dot{I}_b \\ \dot{I}_c \end{bmatrix}$$



# 7-1 对称分量法在不对称短路计算中的应用

## 2. 序阻抗的概念——三相对称电路

$$\begin{bmatrix} \Delta \dot{V}_a \\ \Delta \dot{V}_b \\ \Delta \dot{V}_c \end{bmatrix} = \begin{bmatrix} z_{aa} & z_{ab} & z_{ca} \\ z_{ab} & z_{bb} & z_{bc} \\ z_{ca} & z_{bc} & z_{cc} \end{bmatrix} \begin{bmatrix} \dot{I}_a \\ \dot{I}_b \\ \dot{I}_c \end{bmatrix}$$



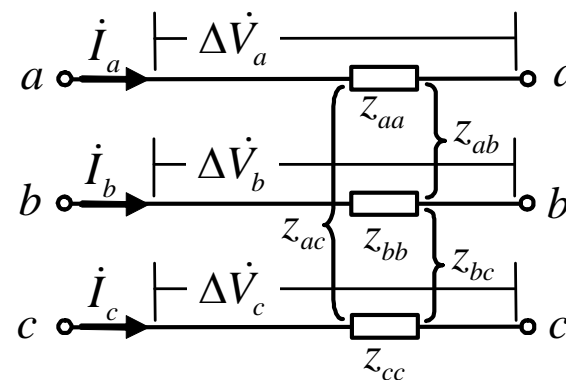
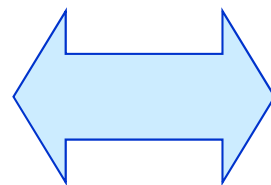
$$\Delta \dot{\mathbf{V}}_{abc} = \mathbf{Z} \dot{\mathbf{I}}_{abc}$$

$$\Delta \dot{\mathbf{V}}_{120} = \mathbf{S} \Delta \dot{\mathbf{V}}_{abc} = \mathbf{S} \mathbf{Z} \mathbf{S}^{-1} \mathbf{S} \dot{\mathbf{I}}_{abc} = \mathbf{Z}_{SC} \dot{\mathbf{I}}_{120}$$

# 7-1 对称分量法在不对称短路计算中的应用

## 2. 序阻抗的概念——三相对称电路

$$\begin{bmatrix} \Delta \dot{V}_a \\ \Delta \dot{V}_b \\ \Delta \dot{V}_c \end{bmatrix} = \begin{bmatrix} z_{aa} & z_{ab} & z_{ca} \\ z_{ab} & z_{bb} & z_{bc} \\ z_{ca} & z_{bc} & z_{cc} \end{bmatrix} \begin{bmatrix} \dot{I}_a \\ \dot{I}_b \\ \dot{I}_c \end{bmatrix}$$



$$\Delta \dot{\mathbf{V}}_{abc} = \mathbf{Z} \dot{\mathbf{I}}_{abc}$$

$$\Delta \dot{\mathbf{V}}_{120} = \mathbf{S} \Delta \dot{\mathbf{V}}_{abc} = \mathbf{S} \mathbf{Z} \mathbf{S}^{-1} \mathbf{S} \dot{\mathbf{I}}_{abc} = \mathbf{Z}_{SC} \dot{\mathbf{I}}_{120}$$

$$\begin{bmatrix} \Delta \dot{V}_{a(1)} \\ \Delta \dot{V}_{a(2)} \\ \Delta \dot{V}_{a(0)} \end{bmatrix} = \begin{bmatrix} z_s - z_m & 0 & 0 \\ 0 & z_s - z_m & 0 \\ 0 & 0 & z_s + 2z_m \end{bmatrix} \begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix}$$



三相对称电路

$$z_{aa} = z_{bb} = z_{cc} = z_s$$

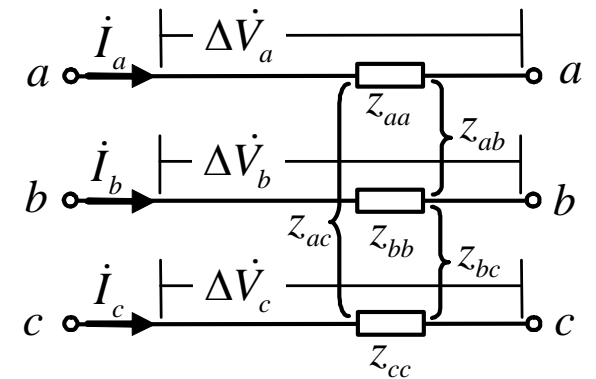
$$z_{ab} = z_{bc} = z_{ca} = z_m$$



# 7-1 对称分量法在不对称短路计算中的应用

## 2. 序阻抗的概念——定义

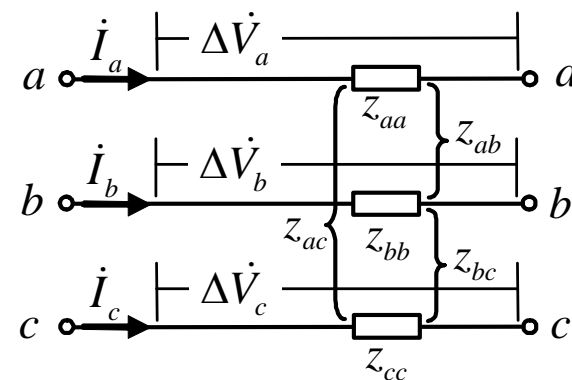
$$\begin{bmatrix} \Delta \dot{V}_{a(1)} \\ \Delta \dot{V}_{a(2)} \\ \Delta \dot{V}_{a(0)} \end{bmatrix} = \begin{bmatrix} z_s - z_m & 0 & 0 \\ 0 & z_s - z_m & 0 \\ 0 & 0 & z_s + 2z_m \end{bmatrix} \begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix}$$



# 7-1 对称分量法在不对称短路计算中的应用

## 2. 序阻抗的概念—定义

$$\begin{bmatrix} \Delta \dot{V}_{a(1)} \\ \Delta \dot{V}_{a(2)} \\ \Delta \dot{V}_{a(0)} \end{bmatrix} = \begin{bmatrix} z_s - z_m & 0 & 0 \\ 0 & z_s - z_m & 0 \\ 0 & 0 & z_s + 2z_m \end{bmatrix} \begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix}$$



$$\Delta \dot{V}_{a(1)} = (z_s - z_m) \dot{I}_{a(1)}$$

$$\Delta \dot{V}_{b(1)} = (z_s - z_m) \dot{I}_{b(1)}$$

$$\Delta \dot{V}_{c(1)} = (z_s - z_m) \dot{I}_{c(1)}$$

$$\Delta \dot{V}_{a(2)} = (z_s - z_m) \dot{I}_{a(2)}$$

$$\Delta \dot{V}_{b(2)} = (z_s - z_m) \dot{I}_{b(2)}$$

$$\Delta \dot{V}_{c(2)} = (z_s - z_m) \dot{I}_{c(2)}$$

$$\Delta \dot{V}_{a(0)} = (z_s + 2z_m) \dot{I}_{a(0)}$$

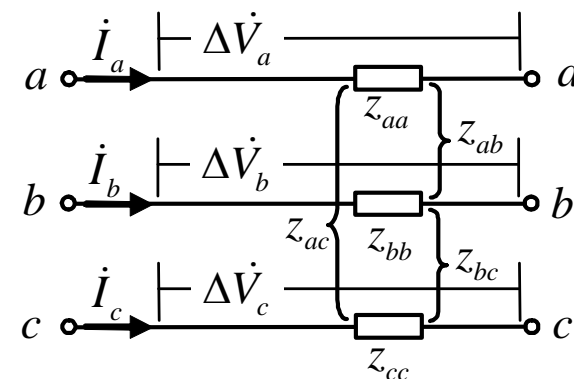
$$\Delta \dot{V}_{b(0)} = (z_s + 2z_m) \dot{I}_{b(0)}$$

$$\Delta \dot{V}_{c(0)} = (z_s + 2z_m) \dot{I}_{c(0)}$$

# 7-1 对称分量法在不对称短路计算中的应用

## 2. 序阻抗的概念—定义

$$\begin{bmatrix} \Delta \dot{V}_{a(1)} \\ \Delta \dot{V}_{a(2)} \\ \Delta \dot{V}_{a(0)} \end{bmatrix} = \begin{bmatrix} z_s - z_m & 0 & 0 \\ 0 & z_s - z_m & 0 \\ 0 & 0 & z_s + 2z_m \end{bmatrix} \begin{bmatrix} \dot{I}_{a(1)} \\ \dot{I}_{a(2)} \\ \dot{I}_{a(0)} \end{bmatrix}$$



$$\Delta \dot{V}_{a(1)} = (z_s - z_m) \dot{I}_{a(1)}$$

$$\Delta \dot{V}_{b(1)} = (z_s - z_m) \dot{I}_{b(1)}$$

$$\Delta \dot{V}_{c(1)} = (z_s - z_m) \dot{I}_{c(1)}$$

$$\Delta \dot{V}_{a(2)} = (z_s - z_m) \dot{I}_{a(2)}$$

$$\Delta \dot{V}_{b(2)} = (z_s - z_m) \dot{I}_{b(2)}$$

$$\Delta \dot{V}_{c(2)} = (z_s - z_m) \dot{I}_{c(2)}$$

$$\Delta \dot{V}_{a(0)} = (z_s + 2z_m) \dot{I}_{a(0)}$$

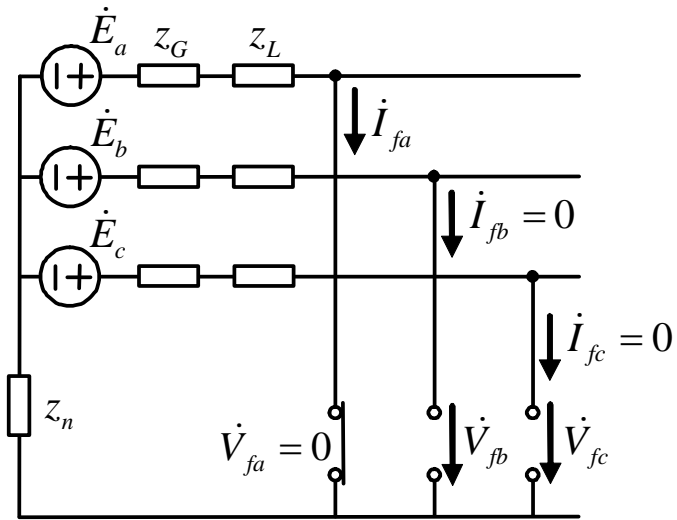
$$\Delta \dot{V}_{b(0)} = (z_s + 2z_m) \dot{I}_{b(0)}$$

$$\Delta \dot{V}_{c(0)} = (z_s + 2z_m) \dot{I}_{c(0)}$$

序阻抗定义:  $z_{(1)} = \Delta \dot{V}_{a(1)} / \dot{I}_{a(1)}$ ,  $z_{(2)} = \Delta \dot{V}_{a(2)} / \dot{I}_{a(2)}$ ,  $z_{(0)} = \Delta \dot{V}_{a(0)} / \dot{I}_{a(0)}$

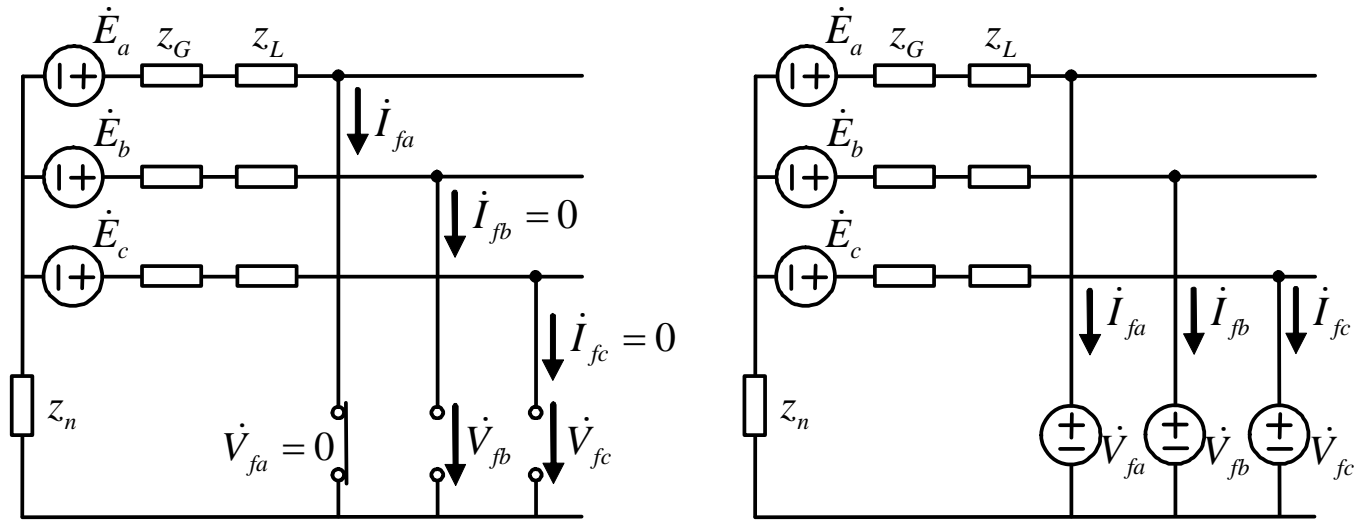
# 7-1 对称分量法在不对称短路计算中的应用

## 3. 对称分量法在不对称短路计算中的应用



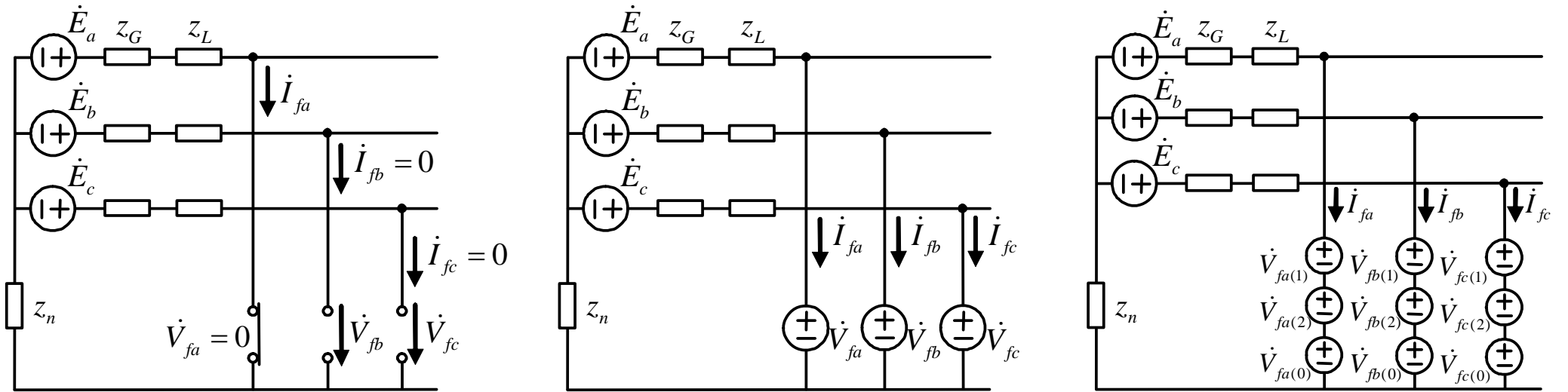
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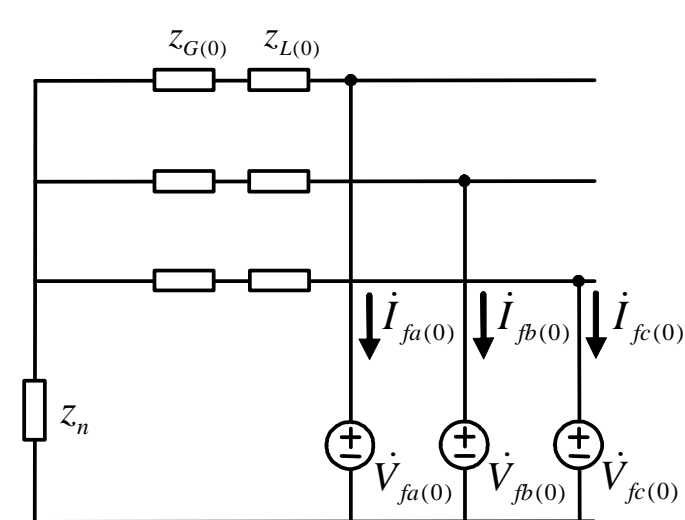
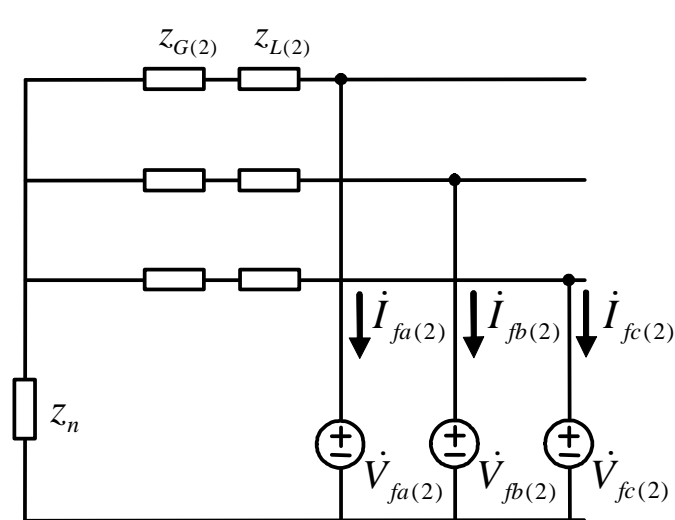
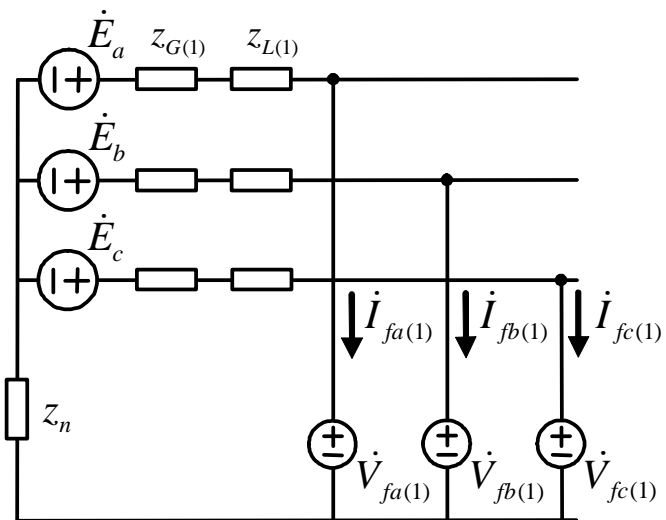
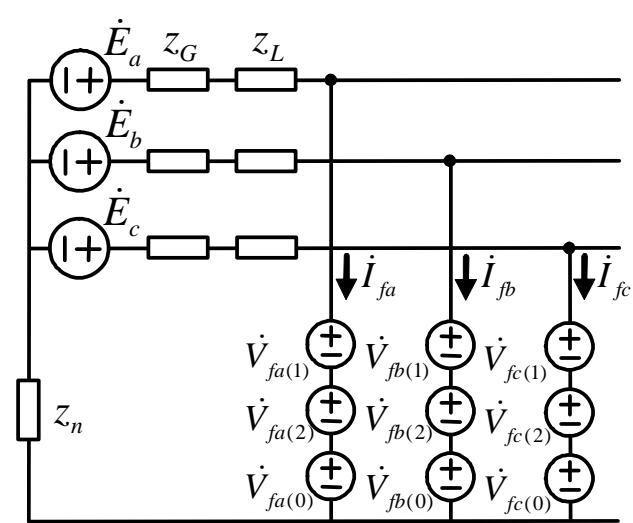
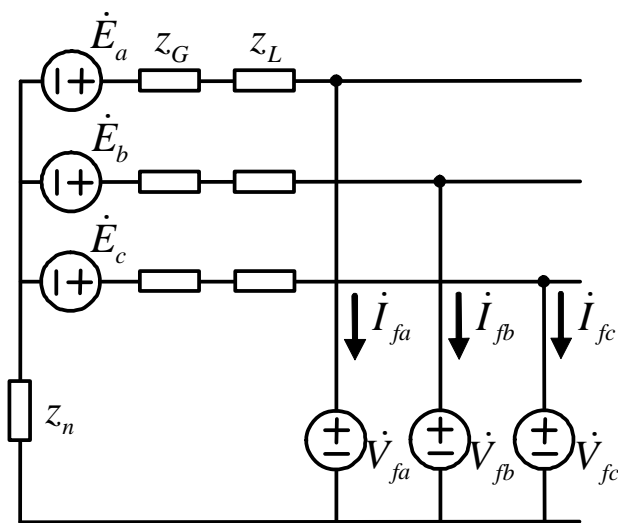
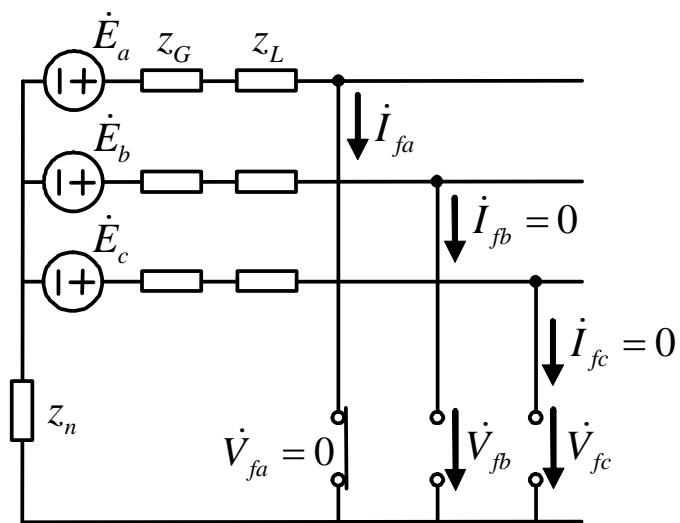
# 7-1 对称分量法在不对称短路计算中的应用

## 3. 对称分量法在不对称短路计算中的应用



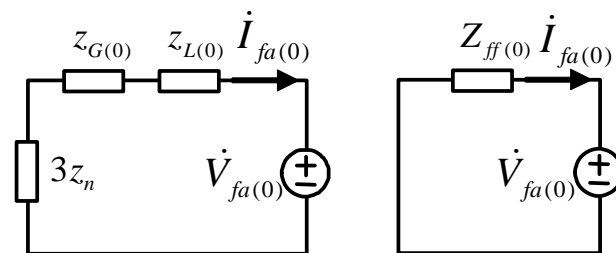
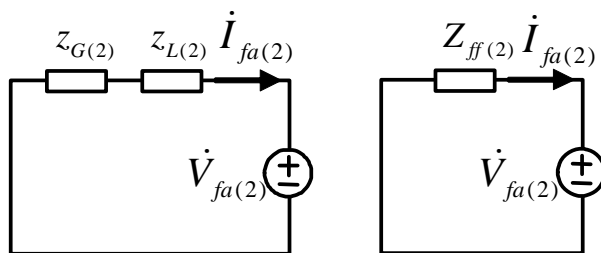
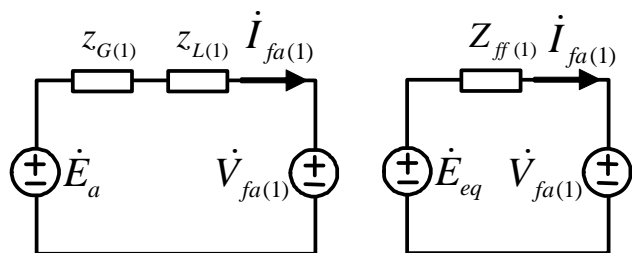
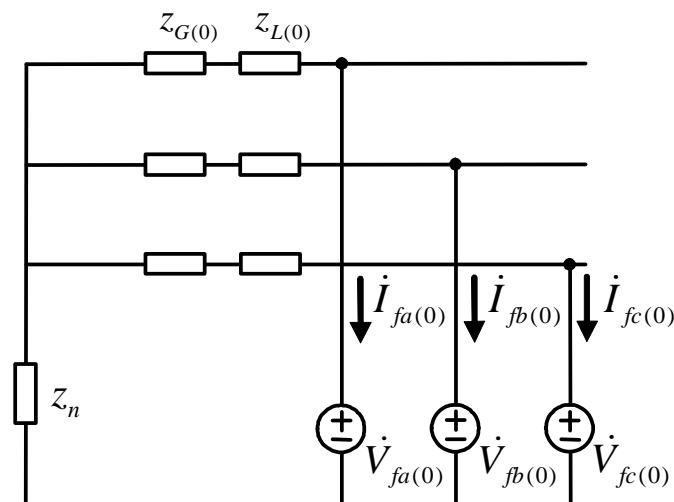
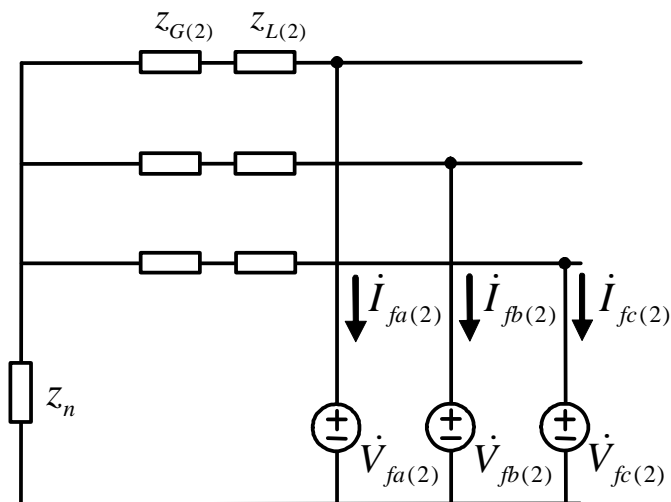
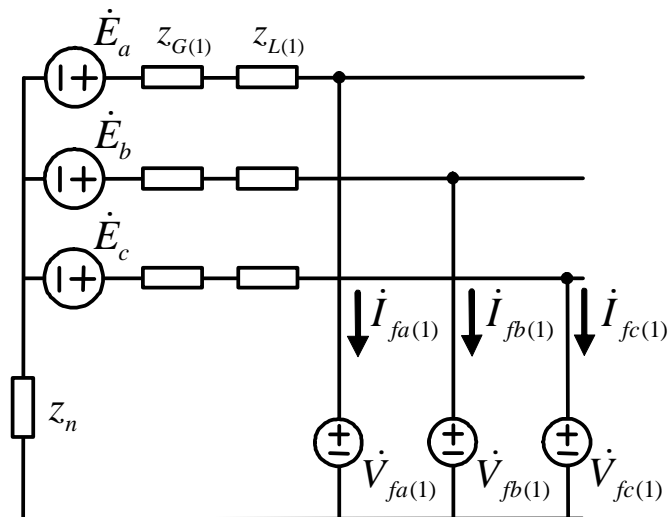
# 7-1 对称分量法在不对称短路计算中的应用

## 3. 对称分量法在不对称短路计算中的应用



# 7-1 对称分量法在不对称短路计算中的应用

## 3. 对称分量法在不对称短路计算中的应用



$$\dot{V}_{fa(1)} = \dot{E}_{eq} - Z_{ff(1)} \dot{I}_{fa(1)}$$

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

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



# 7-1 对称分量法在不对称短路计算中的应用

## 3. 对称分量法在不对称短路计算中的应用

基本方法：用一组不对称电势源代替  
故障口的结构不对称

然后对称分量分解

基本前提：

三相对称——各序分量  
独立；

线性网络——叠加原理；

# 7-1 对称分量法在不对称短路计算中的应用

## 3. 对称分量法在不对称短路计算中的应用

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基本前提：

三相对称——各序分量

独立；

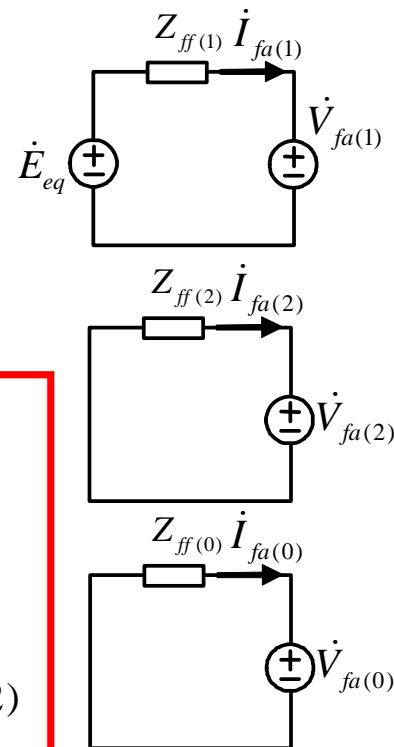
线性网络——叠加原理；

序网方程

$$\dot{V}_{fa(1)} = \dot{E}_{eq} - Z_{ff(1)} \dot{I}_{fa(1)}$$

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

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



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序网方程

$$\dot{V}_{fa(1)} = \dot{E}_{eq} - Z_{ff(1)} \dot{I}_{fa(1)}$$

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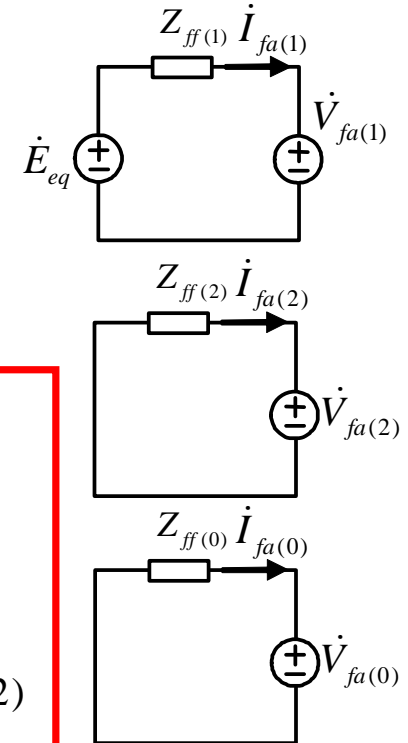
$$\dot{V}_{fa(0)} = -Z_{ff(0)} \dot{I}_{fa(0)}$$

+

故障口边界条件



Solution



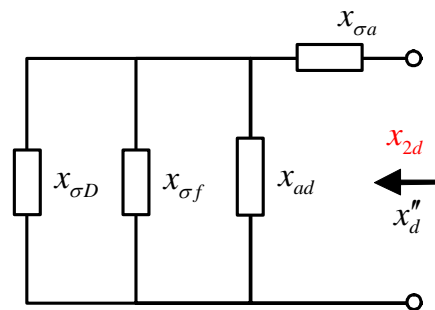
# 7-2 同步电机的负序和零序电抗

## 1. 确定发电机负序电抗的等值电路和计算公式

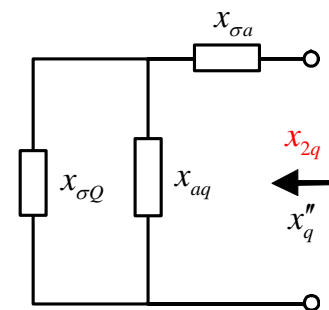
$$f^{(1)}: x_{(2)}^{(1)} = \sqrt{\left(x_d'' + \frac{x_{(0)}}{2}\right)\left(x_q'' + \frac{x_{(0)}}{2}\right)} - \frac{x_{(0)}}{2}$$

$$f^{(2)}: x_{(2)}^{(2)} = \sqrt{x_d'' x_q''}$$

$$f^{(1,1)}: x_{(2)}^{(1,1)} = \frac{x_d'' x_q'' + \sqrt{x_d'' x_q'' (2x_{(0)} + x_d'')(2x_{(0)} + x_q'')}}{2x_{(0)} + x_d'' + x_q''}$$



$$x_{(2)} = \frac{1}{2}(x_d'' + x_q'')$$



$$x_{(2)} = \sqrt{x_d' x_q}$$

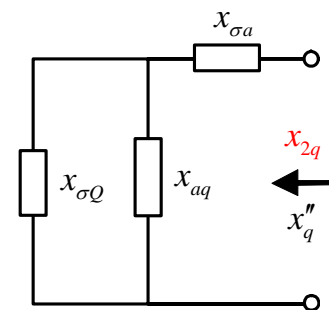
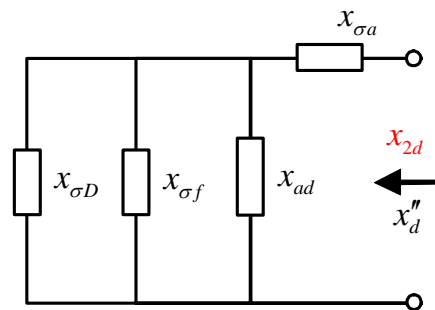
# 7-2 同步电机的负序和零序电抗

## 1. 确定发电机负序电抗的等值电路和计算公式

$$f^{(1)}: x_{(2)}^{(1)} = \sqrt{\left(x_d'' + \frac{x_{(0)}}{2}\right)\left(x_q'' + \frac{x_{(0)}}{2}\right)} - \frac{x_{(0)}}{2}$$

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$$x_{(2)} = \frac{1}{2}(x_d'' + x_q'')$$

$$x_{(2)} = \sqrt{x_d' x_q}$$

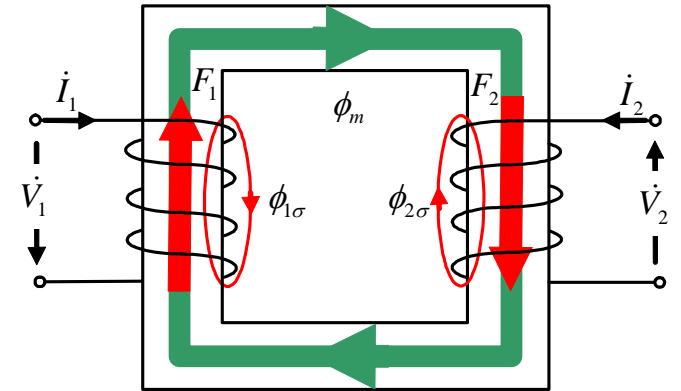
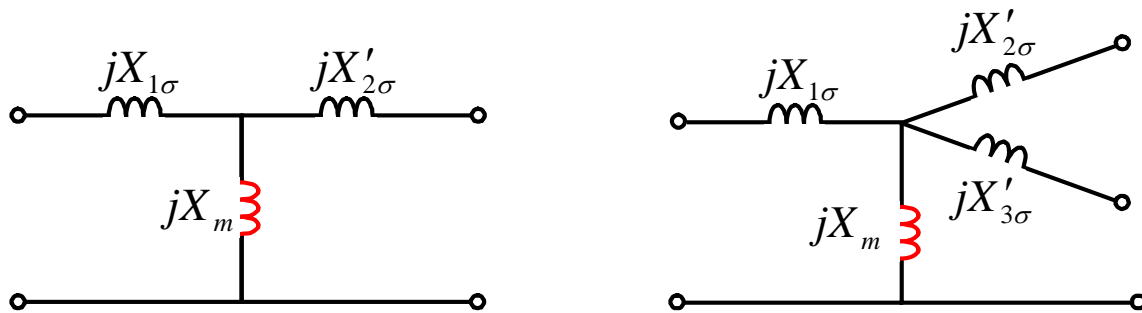
表7-2 同步电机负序和零序电抗的典型值

电机类型	$x_{(2)}$	$x_{(0)}$	电机类型	$x_{(2)}$	$x_{(0)}$
汽轮发电机	0.16	0.06	无阻尼绕组水轮发电机	0.45	0.07
有阻尼绕组水轮发电机	0.25	0.07	同步调相机、大型同步电动机	0.24	0.08

# 7-3 变压器的零序等值电路及其参数

## 1. 普通变压器的零序等值电路——结论1

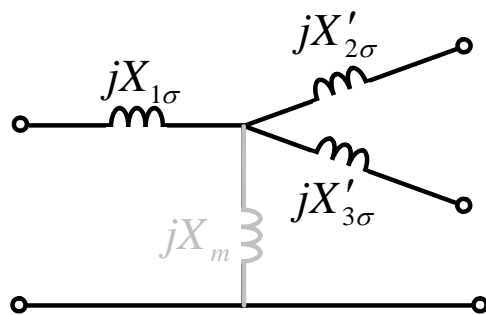
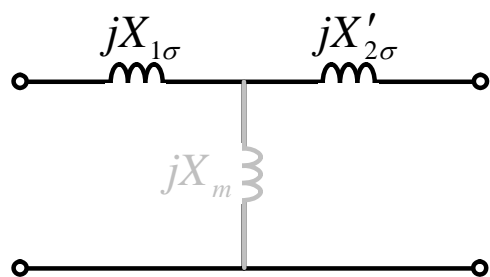
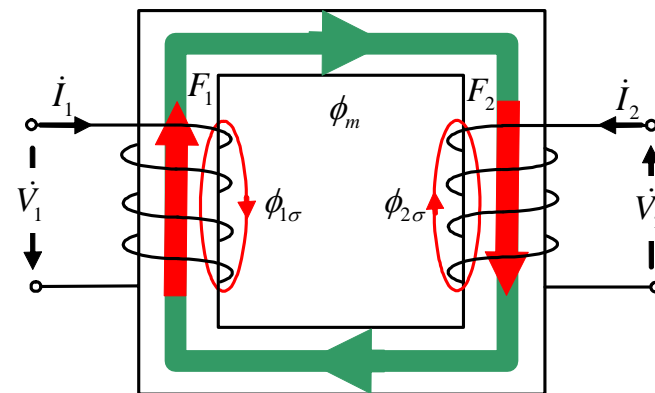
(1) **电路结构相同**——变压器的一相等值电路反应了原副方的电磁耦合关系，对各序电流这种耦合关系相同；



# 7-3 变压器的零序等值电路及其参数

## 1. 普通变压器的零序等值电路——结论2

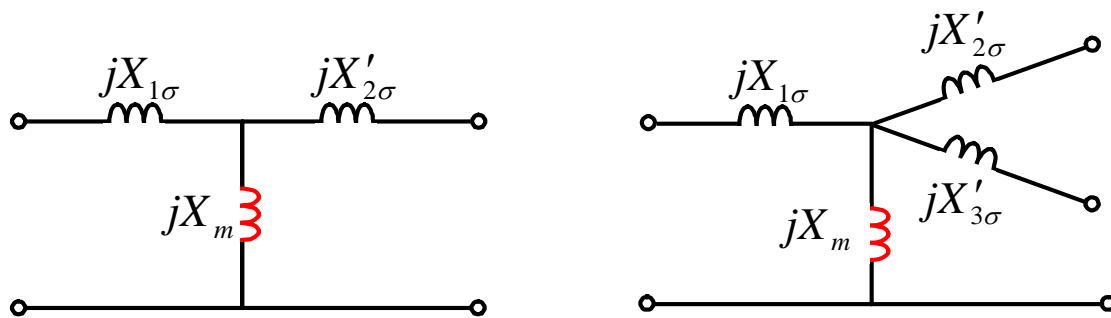
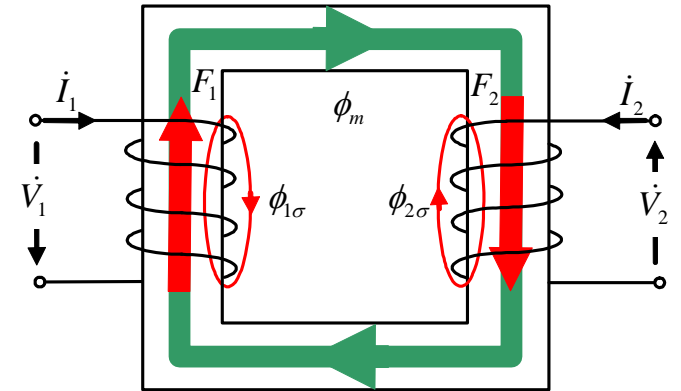
(2) **各序漏电抗相等**——等值电路中采用**漏电抗压降**表示漏磁通感生的电势，漏电抗数值取决于对应的漏磁通路径的磁导率，绕组通过各序电流，其漏磁通路径相同，并且磁导率为常数 $X_{\sigma(1)} = X_{\sigma(2)} = X_{\sigma(0)}$ ;



# 7-3 变压器的零序等值电路及其参数

## 1. 普通变压器的零序等值电路——结论3

(3) **激磁电抗**——变压器主磁通感生的电势用**激磁电抗**压降表示，激磁电抗数值取决于主磁通路径的磁导率；

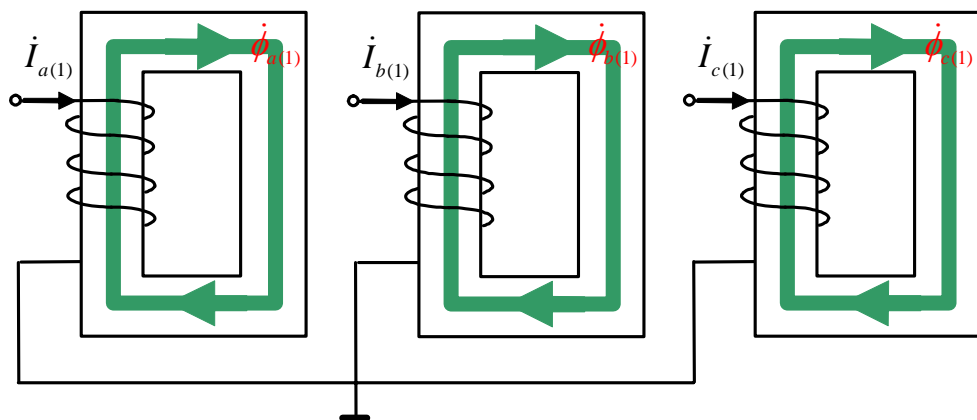
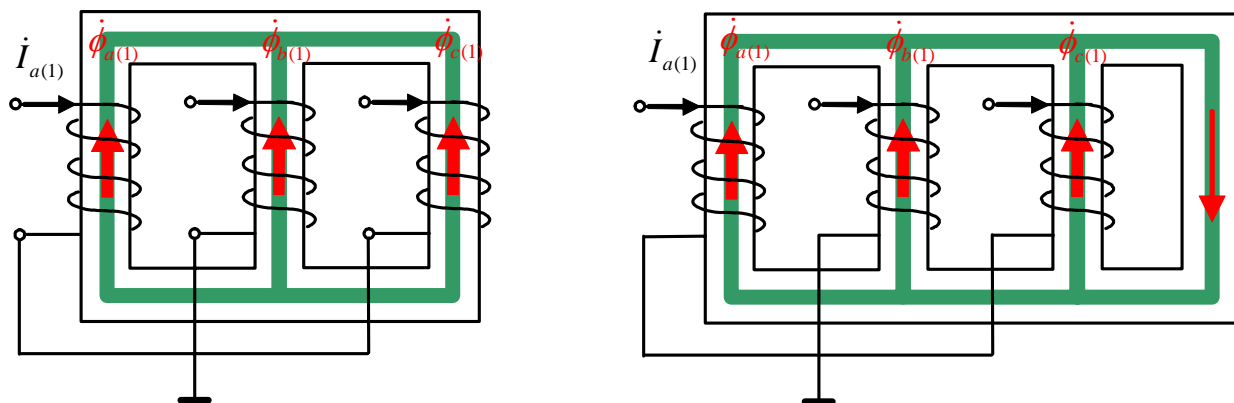




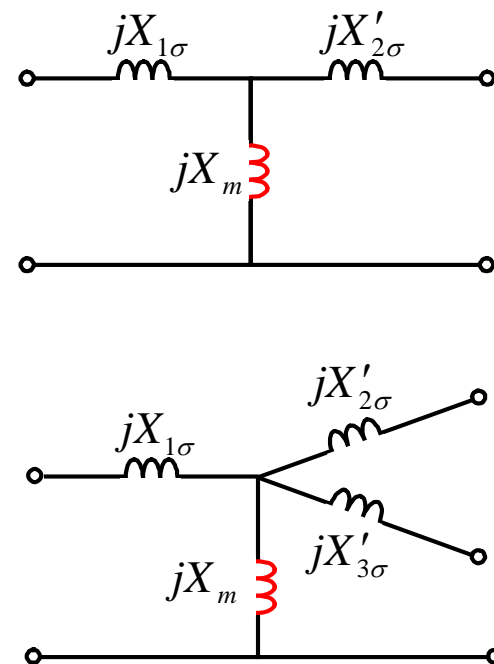
# 7-3 变压器的零序等值电路及其参数

## 1. 普通变压器的零序等值电路——结论4

(4) 绕组通过正序或者负序电流，主磁通路径都是铁芯， $X_{m(1)} = X_{m(2)}$ ，并且磁导率远大于漏磁通路径，因此 $X_{m(1)}$ 远大于 $X_{\sigma(1)}$ ;



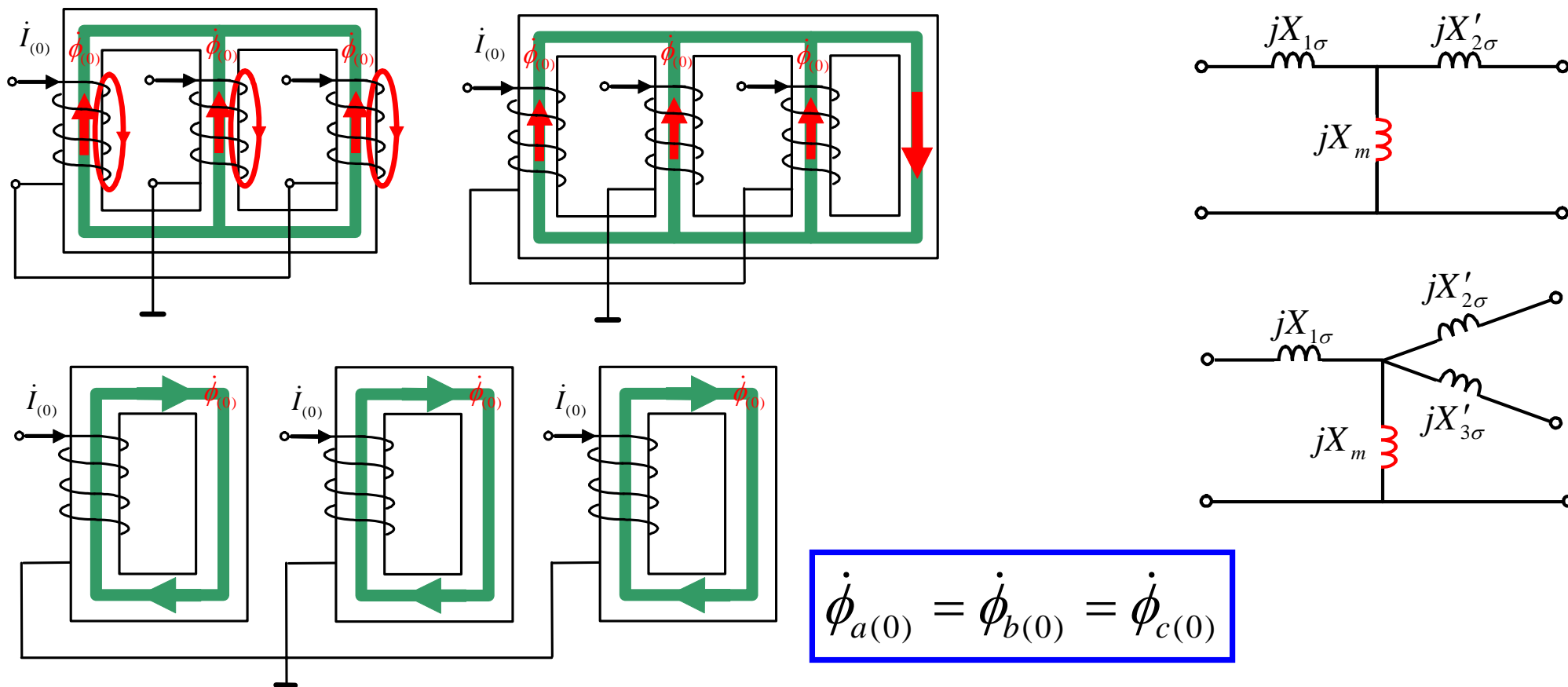
$$\dot{\phi}_{a(1)} + \dot{\phi}_{b(1)} + \dot{\phi}_{c(1)} = 0$$



# 7-3 变压器的零序等值电路及其参数

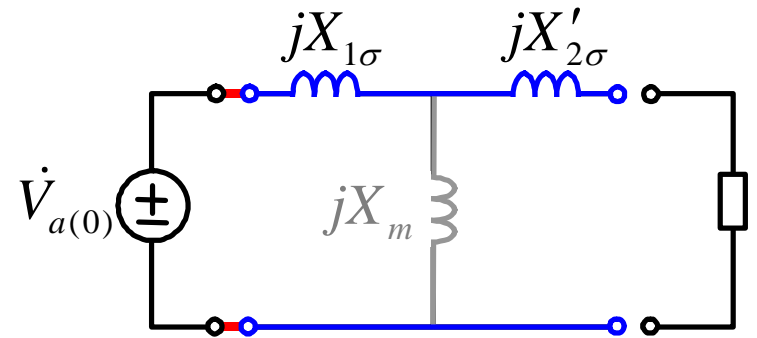
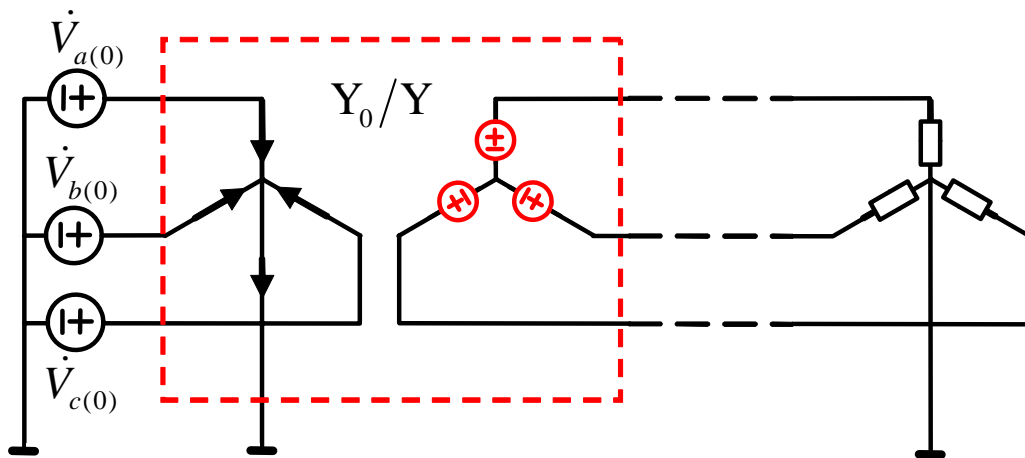
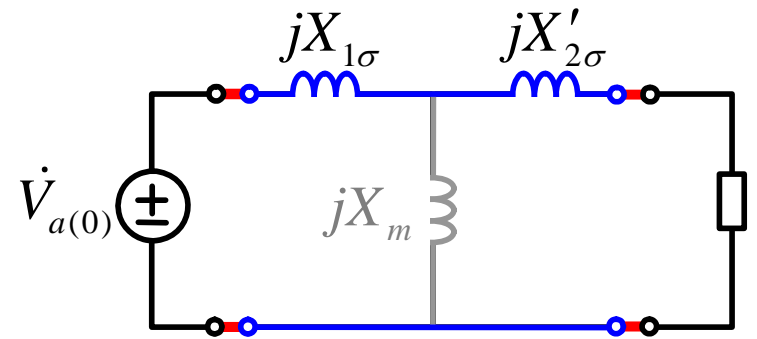
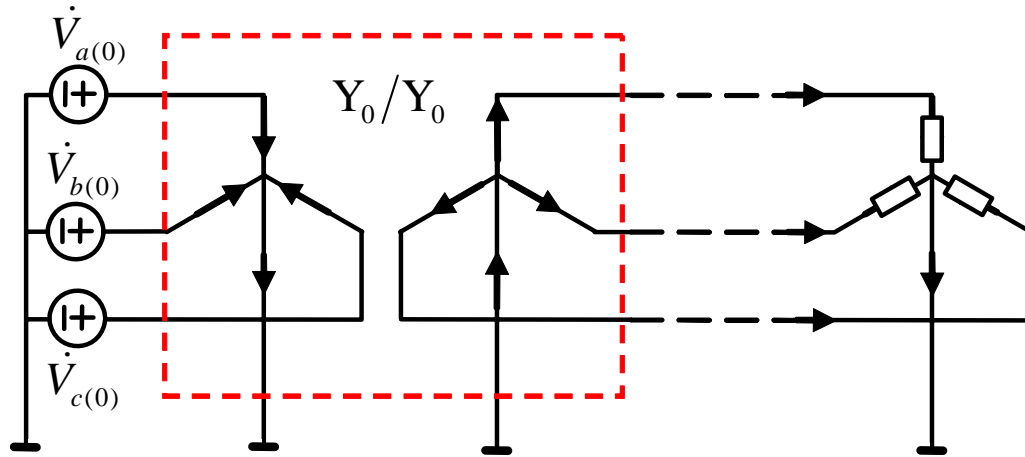
## 1. 普通变压器的零序等值电路——结论5

(5) 绕组通过零序电流，三相三柱式变压器零序主磁通路径只能沿铁芯和空气构成回路，磁导率与漏磁通路径相当，因此  $X_{m(0)} < X_{m(1)}$ ；其他铁芯结构，  $X_{m(0)} = X_{m(1)}$ ；



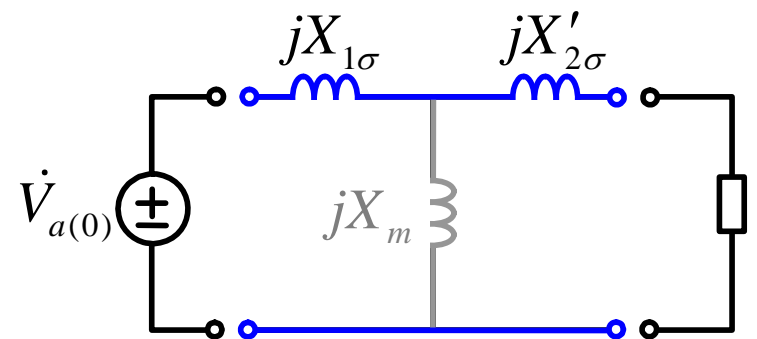
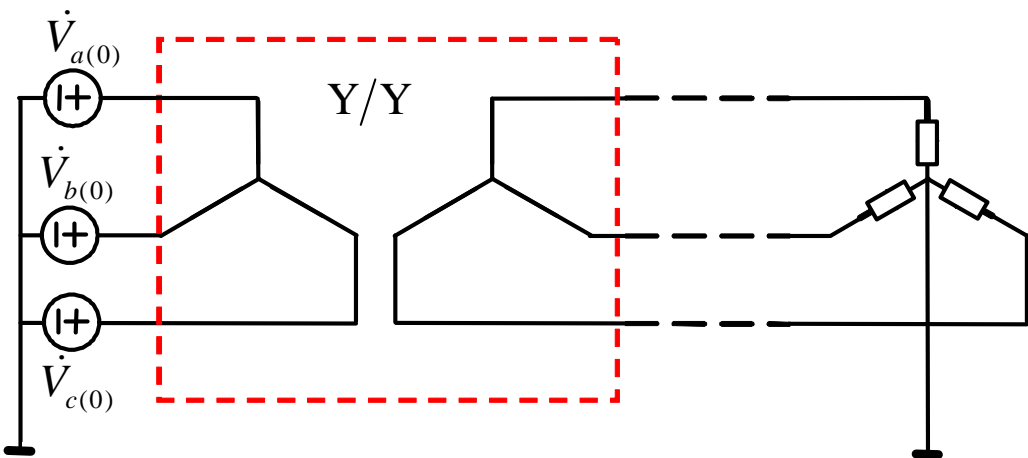
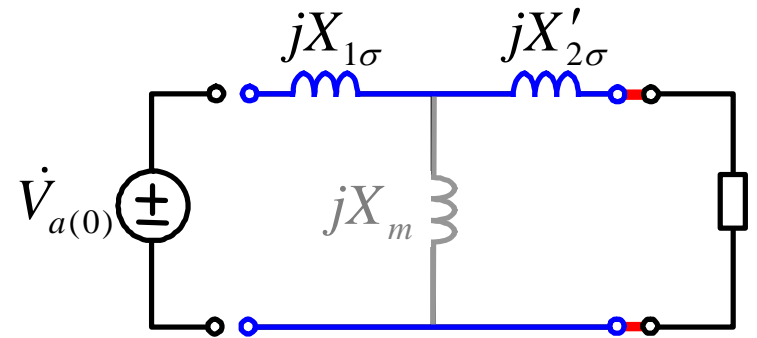
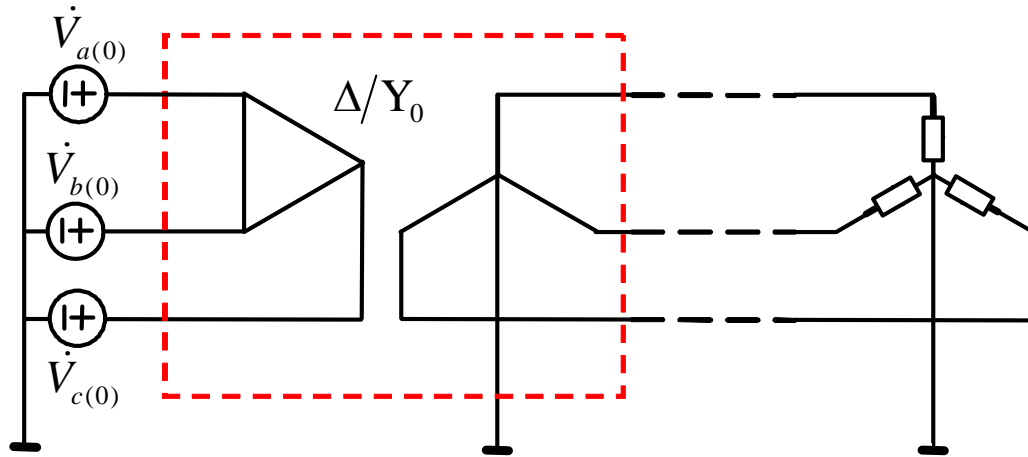
# 7-3 变压器的零序等值电路及其参数

## 2. 变压器的零序等值电路与外电路的联接



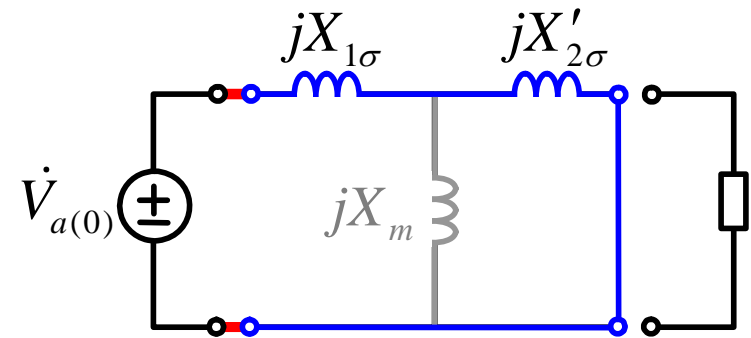
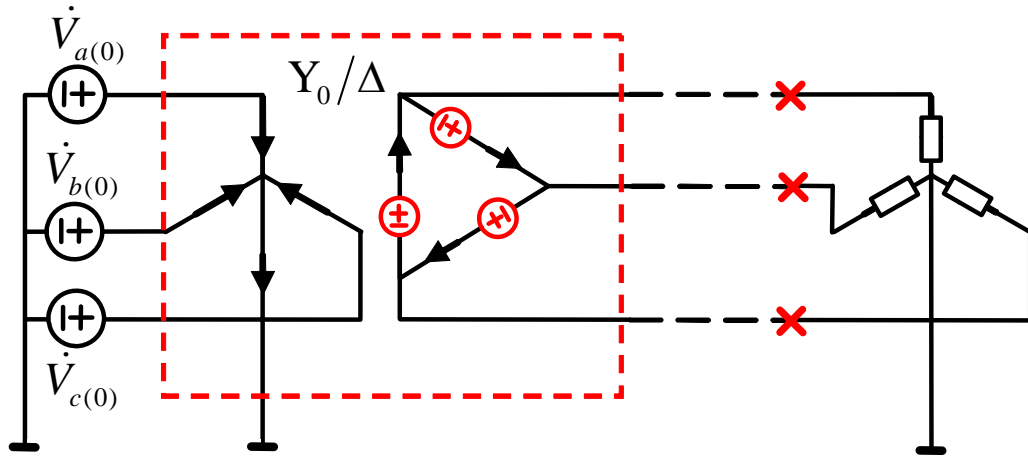
# 7-3 变压器的零序等值电路及其参数

## 2. 变压器的零序等值电路与外电路的联接

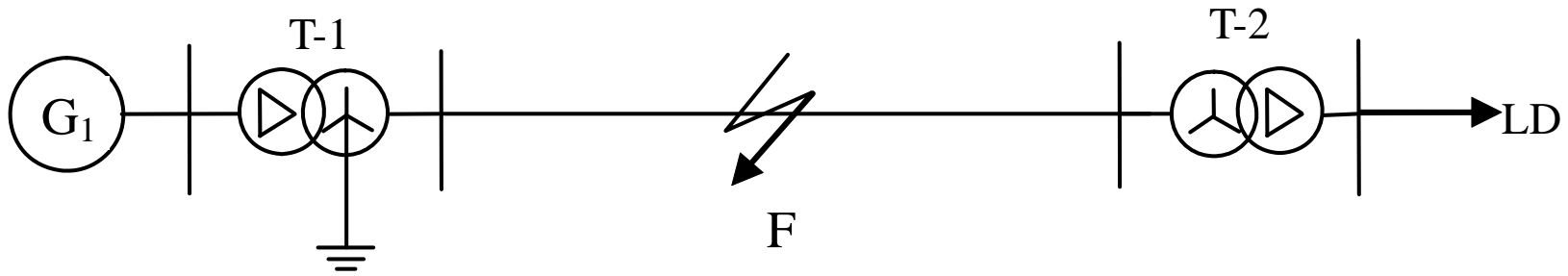


# 7-3 变压器的零序等值电路及其参数

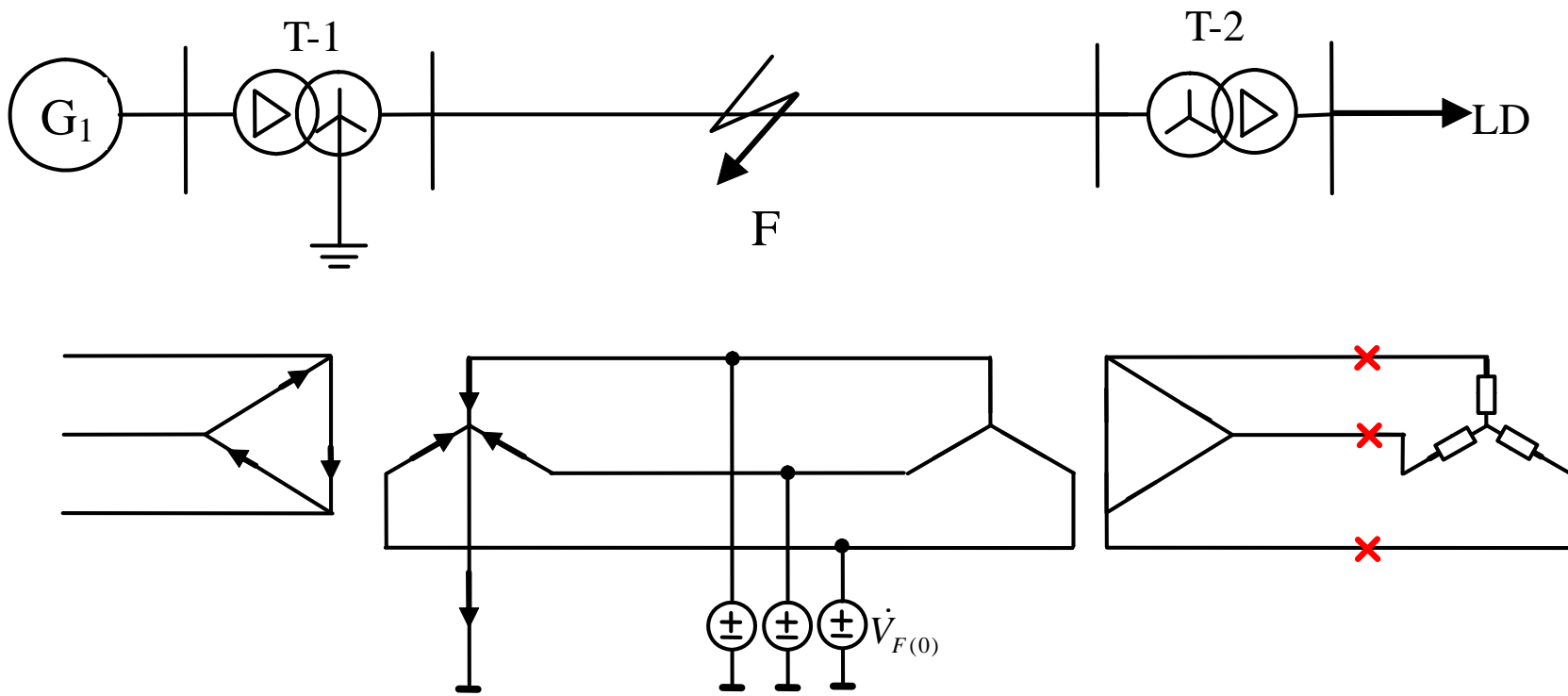
## 2. 变压器的零序等值电路与外电路的联接



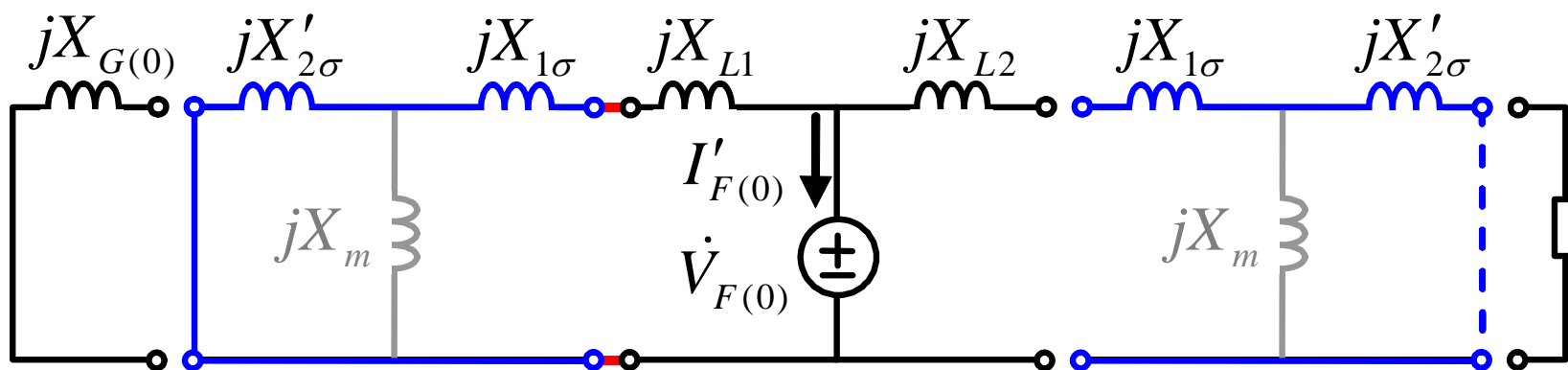
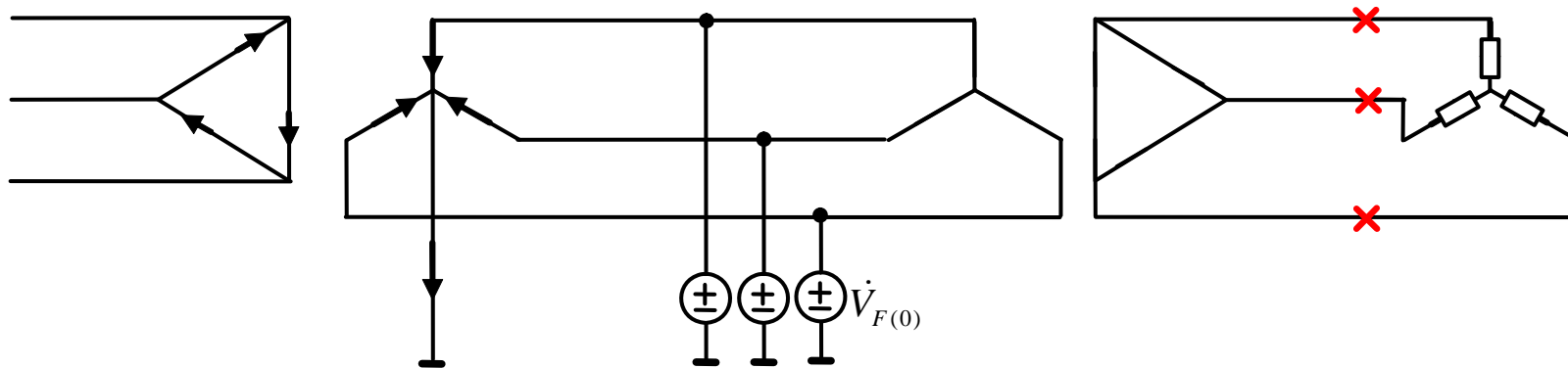
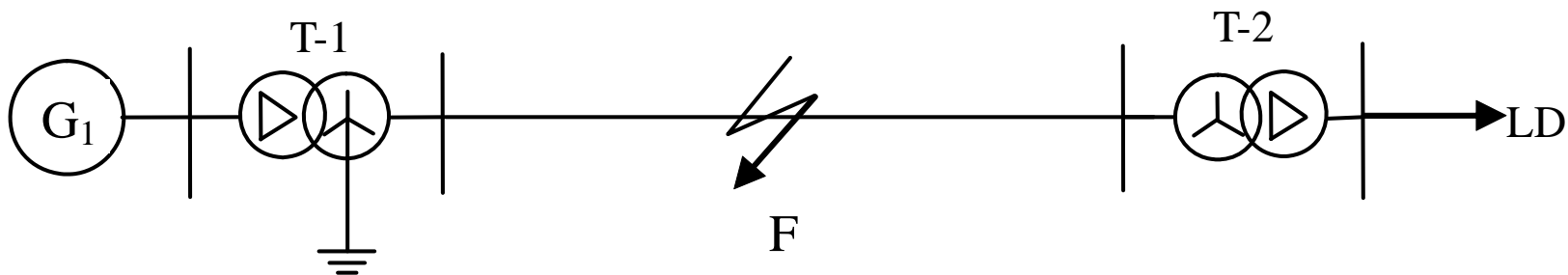
## 2. 变压器的零序等值电路与外电路的联接——举例



## 2. 变压器的零序等值电路与外电路的联接——举例

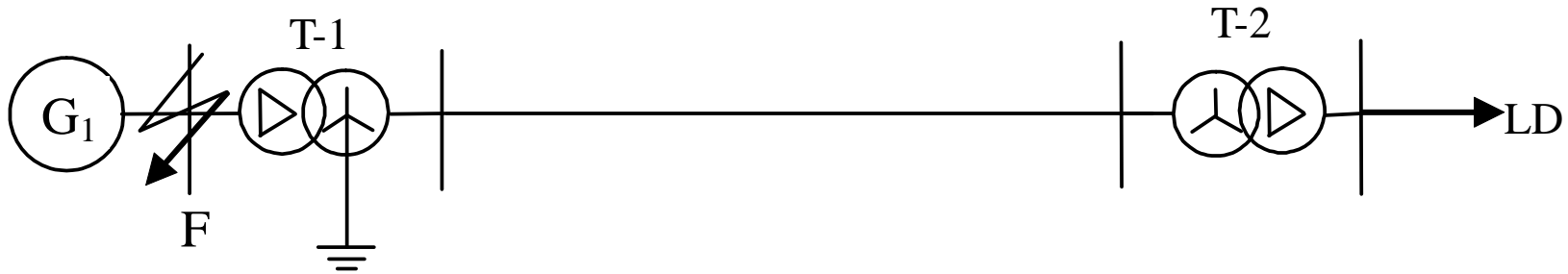


## 2. 变压器的零序等值电路与外电路的联接——举例

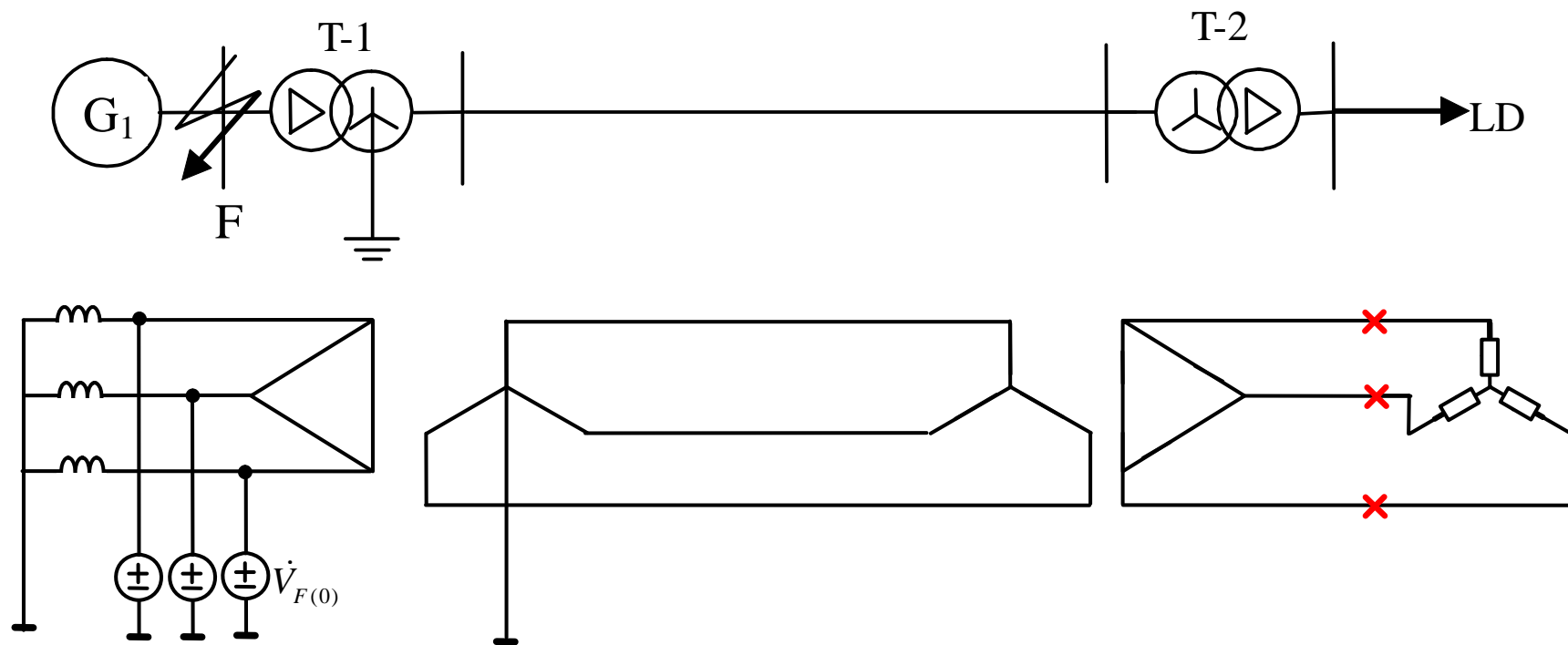




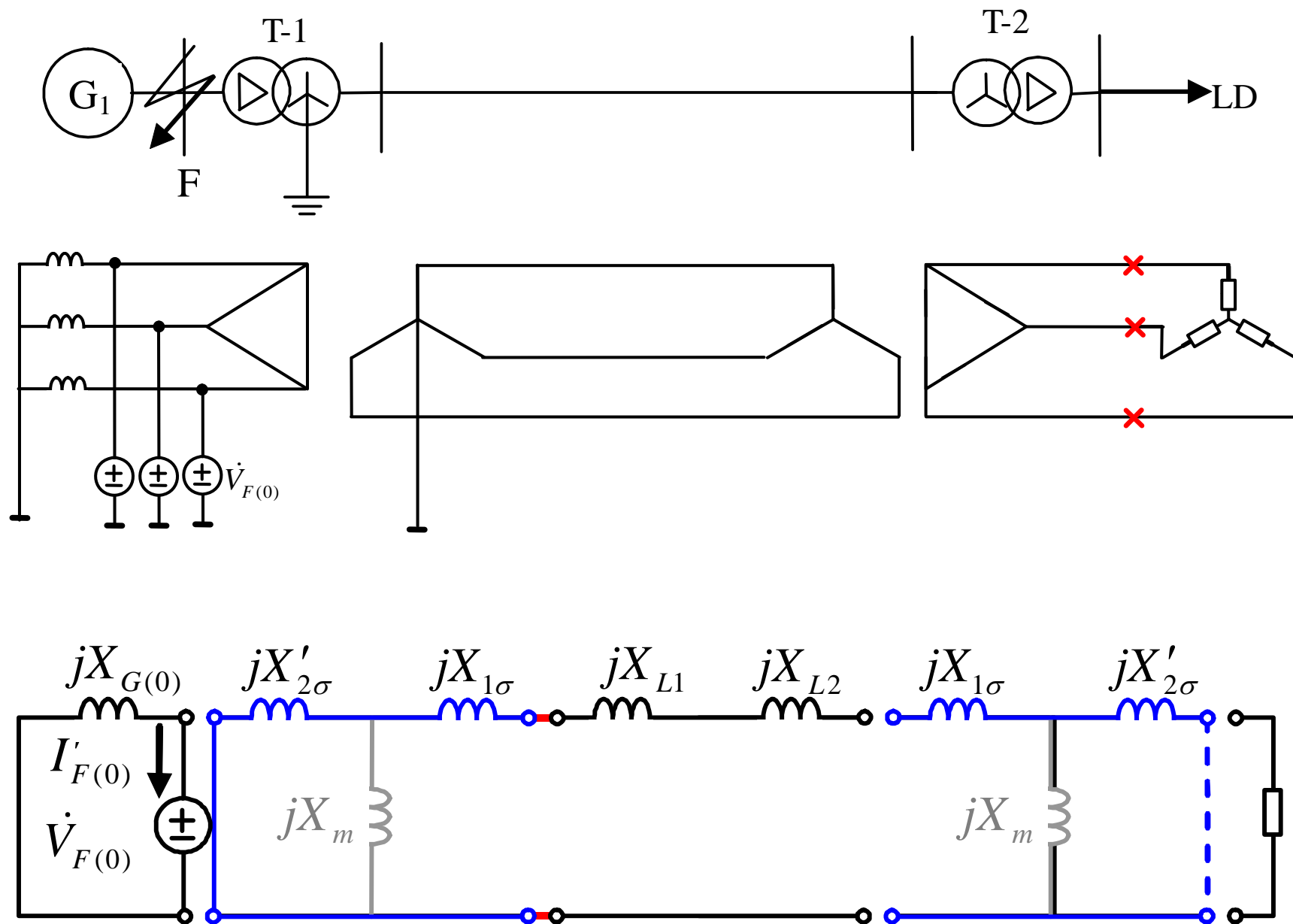
## 2. 变压器的零序等值电路与外电路的联接——**举例**



## 2. 变压器的零序等值电路与外电路的联接——举例

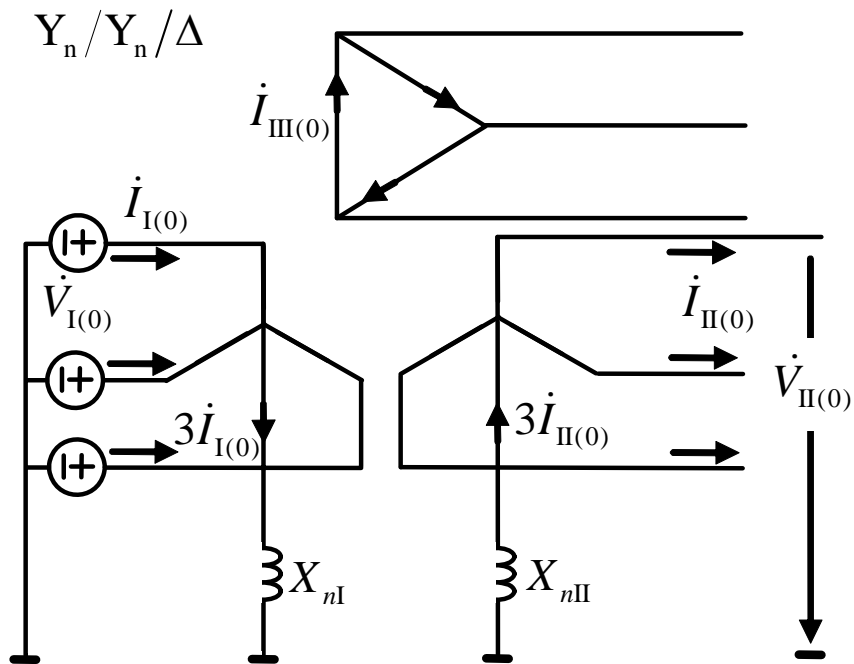


## 2. 变压器的零序等值电路与外电路的联接——举例



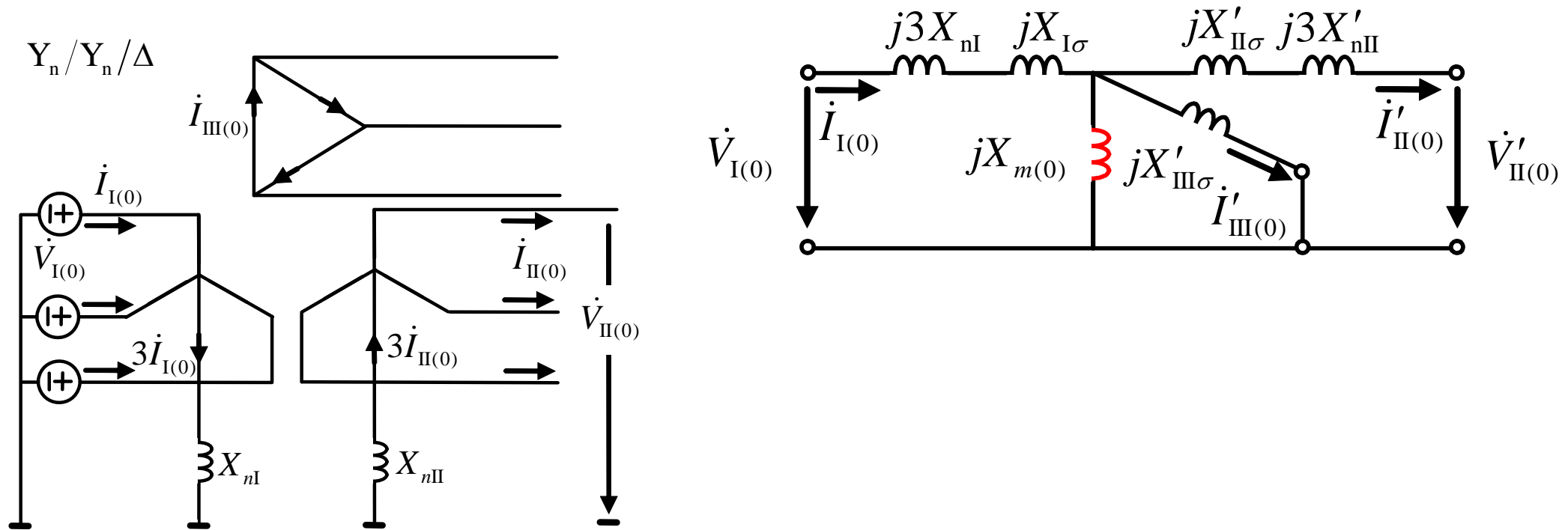
## 7-3 变压器的零序等值电路及其参数

### 3. 中性点有接地阻抗的变压器零序等值电路



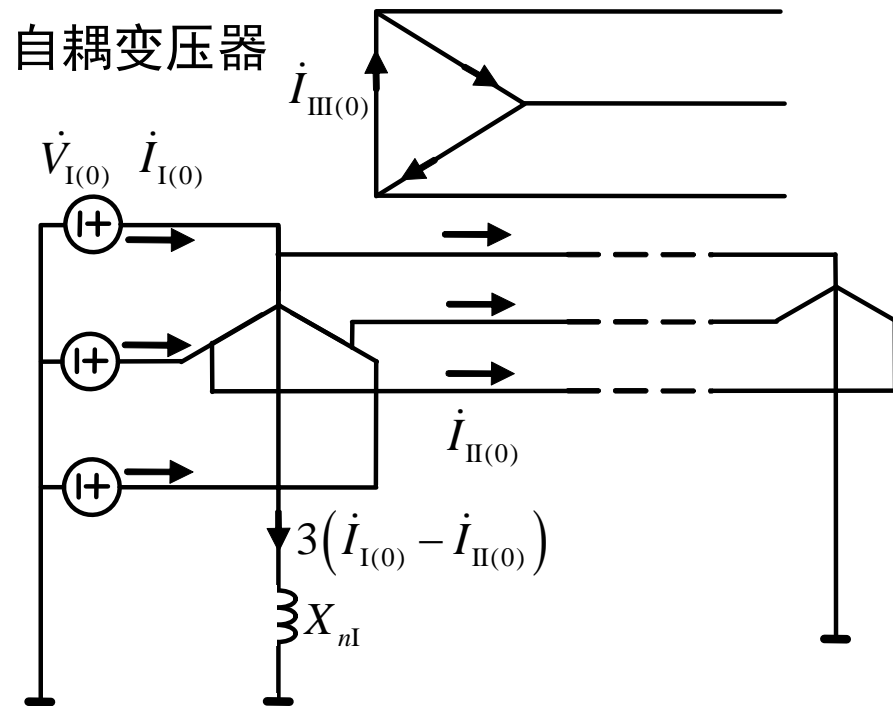
# 7-3 变压器的零序等值电路及其参数

## 3. 中性点有接地阻抗的变压器零序等值电路



## 7-3 变压器的零序等值电路及其参数

### 4. 自耦变压器的零序等值电路及其参数\*



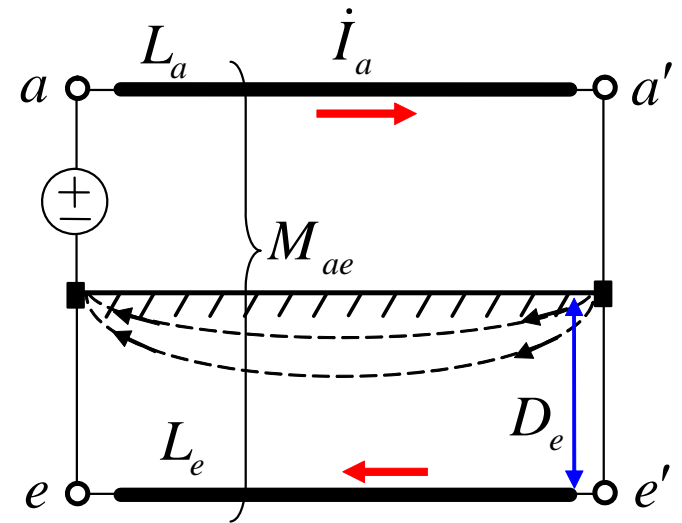
自耦变压器的特点:

- (1) 原副方之间有直接的电气联系;
- (2) 中性点入地电流取决于原副方零序电流
- (3) 中性点接地阻抗对各侧绕组零序参数均有影响;

## 7-4 架空输电线的零序阻抗及其等值电路

### 1. 单导线—大地回路的自阻抗

**自阻抗:**单导线以大地为回路时对应于单位长度导线的回路阻抗



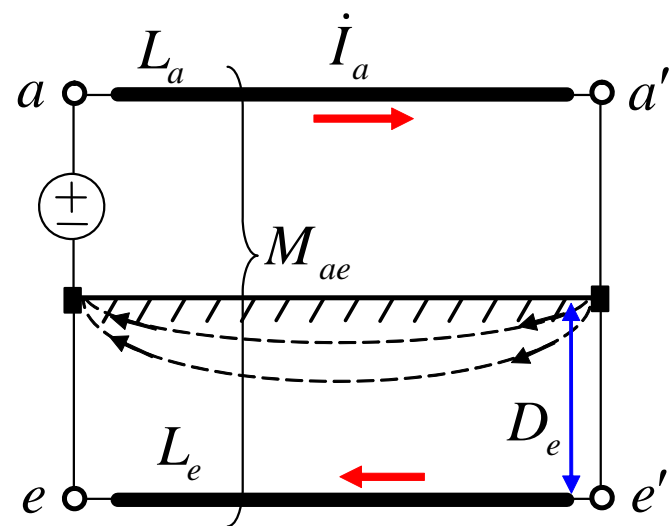
## 7-4 架空输电线的零序阻抗及其等值电路

### 1. 单导线—大地回路的自阻抗

**自阻抗:**单导线以大地为回路时对应于单位长度导线的回路阻抗

$$\{L\}_{\text{H/m}} = \frac{\mu_0}{2\pi} \left[ \ln \frac{2l}{D_s} - 1 \right]$$

$$\{M\}_{\text{H/m}} = \frac{\mu_0}{2\pi} \left[ \ln \frac{2l}{D} - 1 \right]$$





## 7-4 架空输电线的零序阻抗及其等值电路

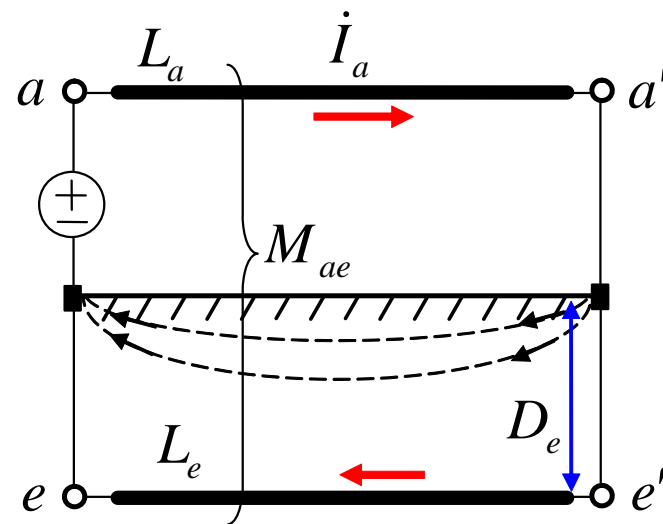
### 1. 单导线—大地回路的自阻抗

**自阻抗:**单导线以大地为回路时对应于单位长度导线的回路阻抗

$$\{L\}_{\text{H/m}} = \frac{\mu_0}{2\pi} \left[ \ln \frac{2l}{D_s} - 1 \right]$$

$$\{M\}_{\text{H/m}} = \frac{\mu_0}{2\pi} \left[ \ln \frac{2l}{D} - 1 \right]$$

$$\{L_S\}_{\text{H/m}} = L_a + L_e - 2M_{ae} = 2 \times 10^{-7} \ln \frac{D_e}{D_s}$$



## 7-4 架空输电线的零序阻抗及其等值电路

### 1. 单导线—大地回路的自阻抗

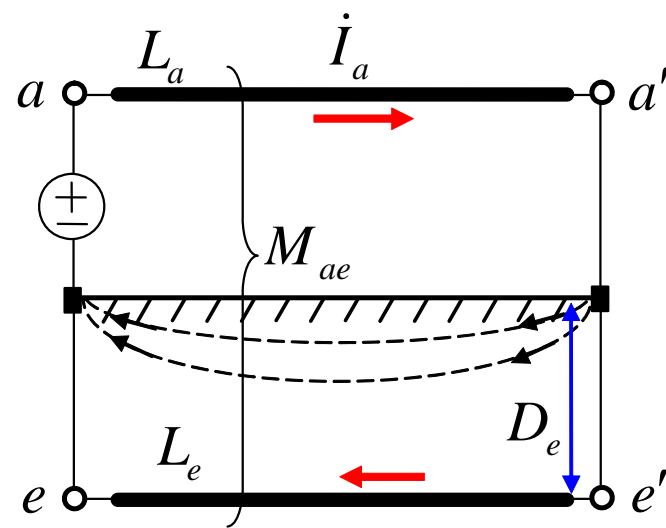
**自阻抗:**单导线以大地为回路时对应于单位长度导线的回路阻抗

$$\{L\}_{\text{H/m}} = \frac{\mu_0}{2\pi} \left[ \ln \frac{2l}{D_s} - 1 \right]$$

$$\{M\}_{\text{H/m}} = \frac{\mu_0}{2\pi} \left[ \ln \frac{2l}{D} - 1 \right]$$

$$\{L_S\}_{\text{H/m}} = L_a + L_e - 2M_{ae} = 2 \times 10^{-7} \ln \frac{D_e}{D_s}$$

$$\{z_S\}_{\Omega/\text{km}} = r_a + r_e + j\omega L_S = r_a + r_e + j0.1445 \lg \frac{D_e}{D_s}$$



# 7-4 架空输电线的零序阻抗及其等值电路

## 1. 单导线—大地回路的自阻抗

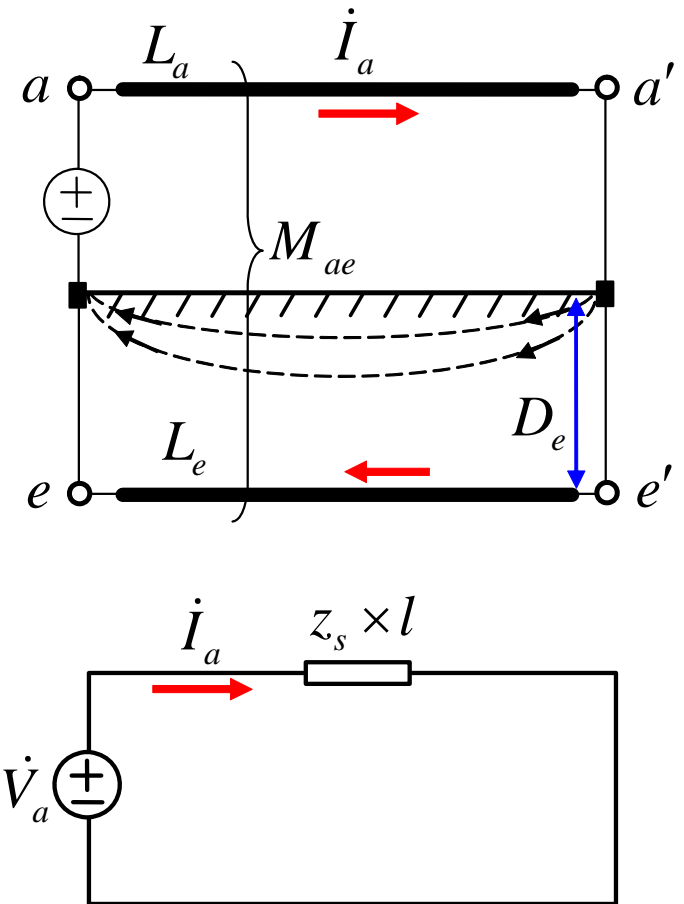
**自阻抗:**单导线以大地为回路时对应于单位长度导线的回路阻抗

$$\{L\}_{\text{H/m}} = \frac{\mu_0}{2\pi} \left[ \ln \frac{2l}{D_s} - 1 \right]$$

$$\{M\}_{\text{H/m}} = \frac{\mu_0}{2\pi} \left[ \ln \frac{2l}{D} - 1 \right]$$

$$\{L_S\}_{\text{H/m}} = L_a + L_e - 2M_{ae} = 2 \times 10^{-7} \ln \frac{D_e}{D_s}$$

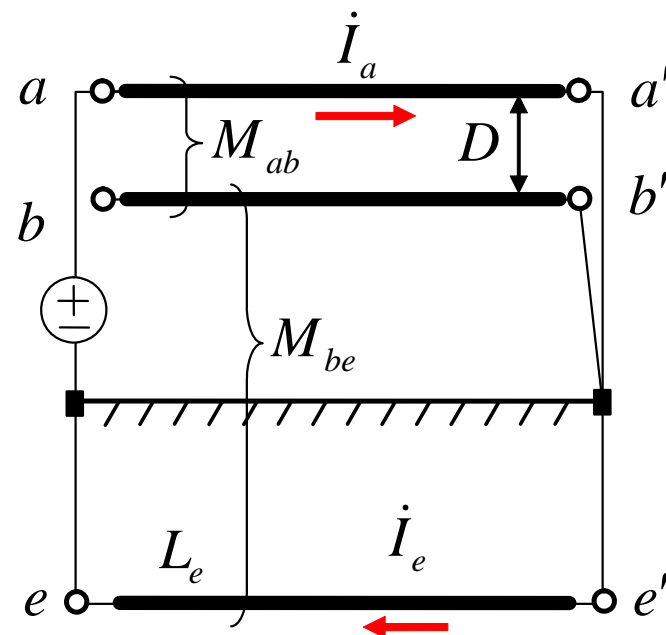
$$\{z_S\}_{\Omega/\text{km}} = r_a + r_e + j\omega L_S = r_a + r_e + j0.1445 \lg \frac{D_e}{D_s}$$



## 7-4 架空输电线的零序阻抗及其等值电路

### 2. 两平行单导线—大地回路间的互阻抗

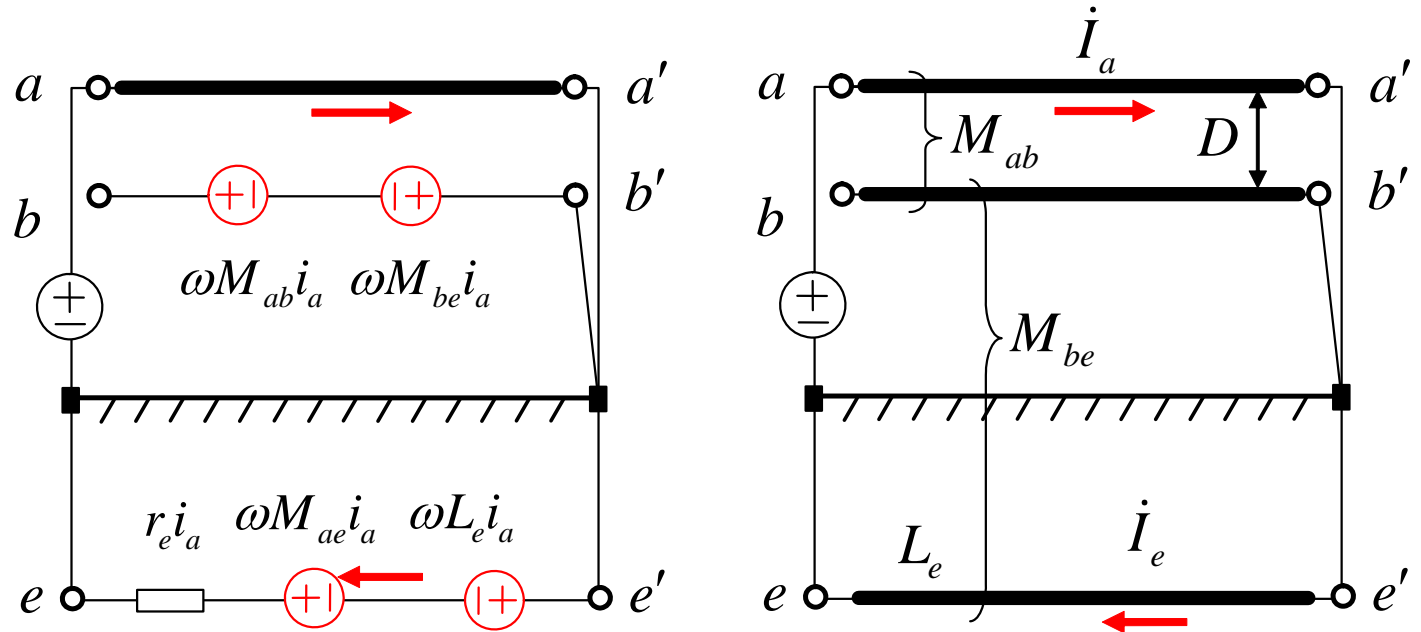
**互阻抗:** 一个回路通过单位电流时, 在另一个回路单位长度上产生的压降



# 7-4 架空输电线的零序阻抗及其等值电路

## 2. 两平行单导线—大地回路间的互阻抗

**互阻抗:** 一个回路通过单位电流时, 在另一个回路单位长度上产生的压降



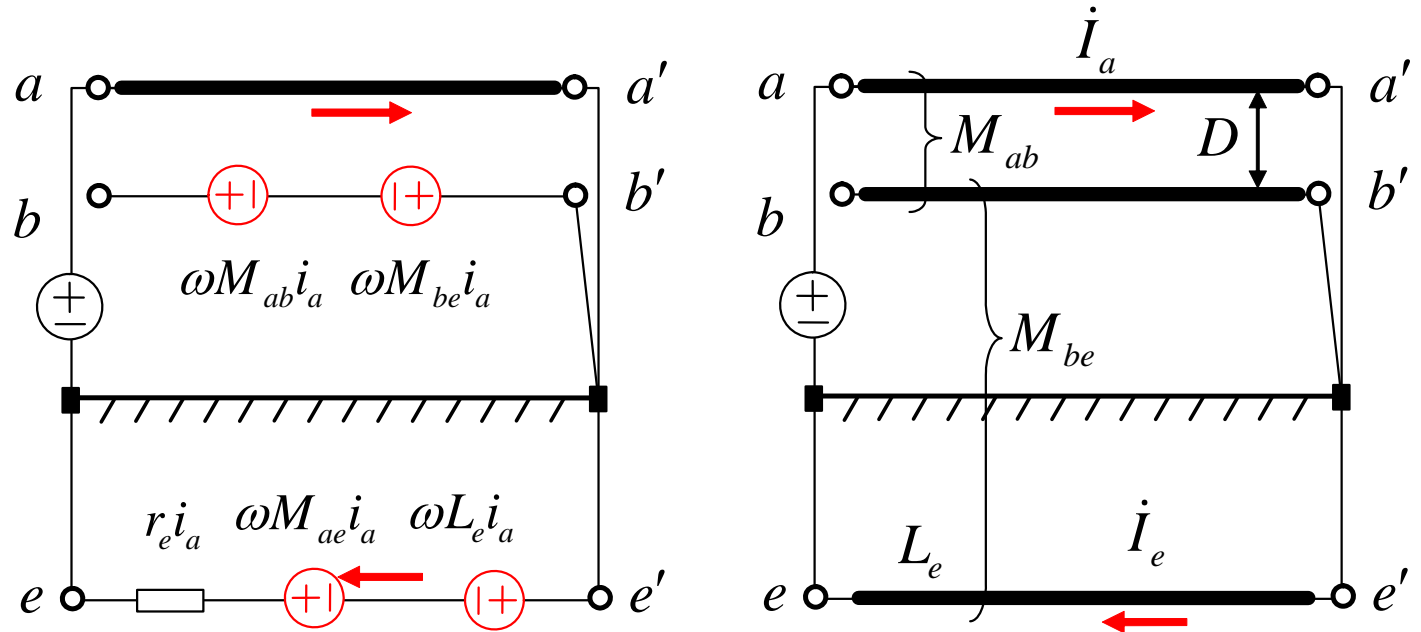
$$\psi_{bb'} = (M_{ab} - M_{be}) i_a$$

$$\psi_{ee'} = (M_{ae} - L_e) i_a$$

# 7-4 架空输电线的零序阻抗及其等值电路

## 2. 两平行单导线—大地回路间的互阻抗

**互阻抗:** 一个回路通过单位电流时, 在另一个回路单位长度上产生的压降



$$\psi_{bb'} = (M_{ab} - M_{be}) i_a$$

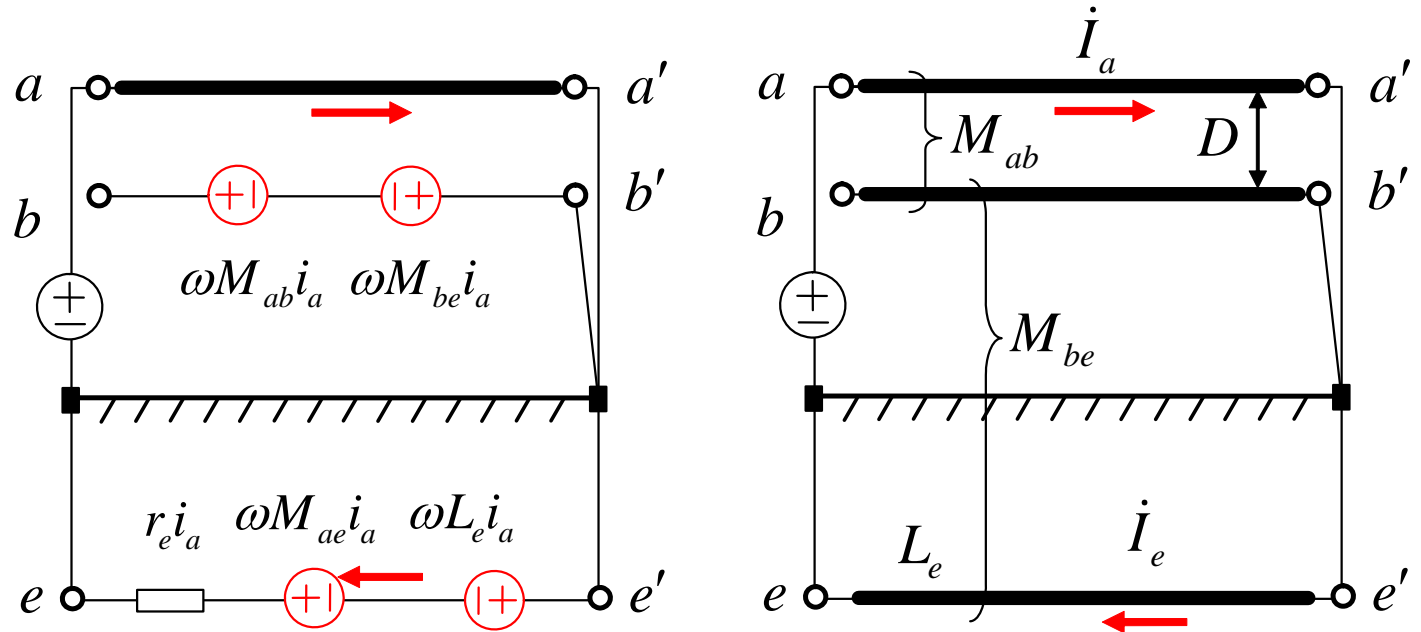
$$\psi_{ee'} = (M_{ae} - L_e) i_a$$

$$\left\{ \Delta \dot{E} \right\}_{\Omega/\text{km}} = j\omega [M_{ab} - M_{be} + L_e - M_{ae}] \dot{I}_a$$

# 7-4 架空输电线的零序阻抗及其等值电路

## 2. 两平行单导线—大地回路间的互阻抗

**互阻抗:** 一个回路通过单位电流时, 在另一个回路单位长度上产生的压降



$$\psi_{bb'} = (M_{ab} - M_{be}) i_a$$

$$\psi_{ee'} = (M_{ae} - L_e) i_a$$

$$\left\{ \Delta \dot{E} \right\}_{\Omega/\text{km}} = j\omega [M_{ab} - M_{be} + L_e - M_{ae}] \dot{I}_a$$

$$\left\{ z_m \right\}_{\Omega/\text{km}} = r_e + j\omega (M_{ab} - M_{be} - M_{ae} + L_e) = r_e + j0.1445 \lg \frac{D_e}{D}$$

## 7-4 架空输电线的零序阻抗及其等值电路

### 3. 三相输电线路的零序阻抗

$$\dot{V}_a = z_s \dot{I}_a + z_m \dot{I}_b + z_m \dot{I}_c$$

$$\dot{V}_{a(1)} = (z_s - z_m) \dot{I}_{a(1)}$$

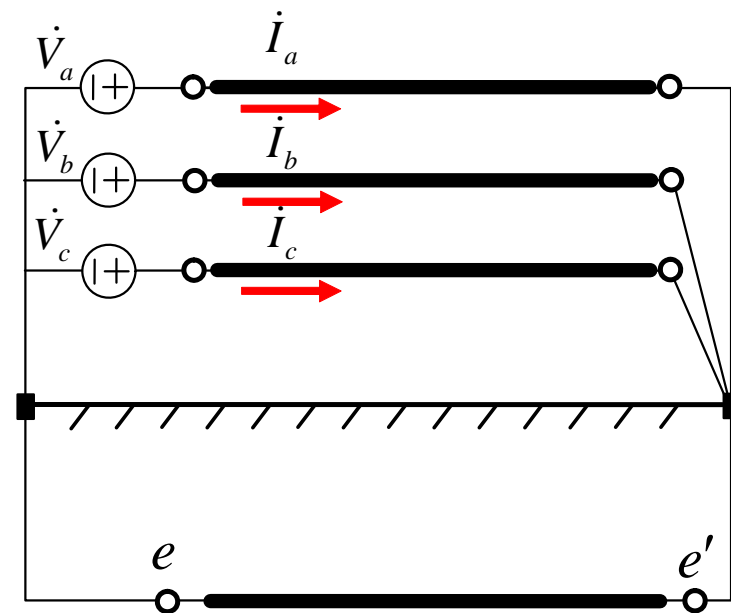
$$\dot{V}_{a(2)} = (z_s - z_m) \dot{I}_{a(2)}$$

$$\dot{V}_{a(0)} = (z_s + 2z_m) \dot{I}_{a(0)}$$

$$z_{(1)} = z_s - z_m$$

$$z_{(2)} = z_s - z_m$$

$$z_{(0)} = z_s + 2z_m$$





## 7-4 架空输电线的零序阻抗及其等值电路

### 3. 三相输电线路的零序阻抗

$$\dot{V}_a = z_s \dot{I}_a + z_m \dot{I}_b + z_m \dot{I}_c$$

$$\dot{V}_{a(1)} = (z_s - z_m) \dot{I}_{a(1)}$$

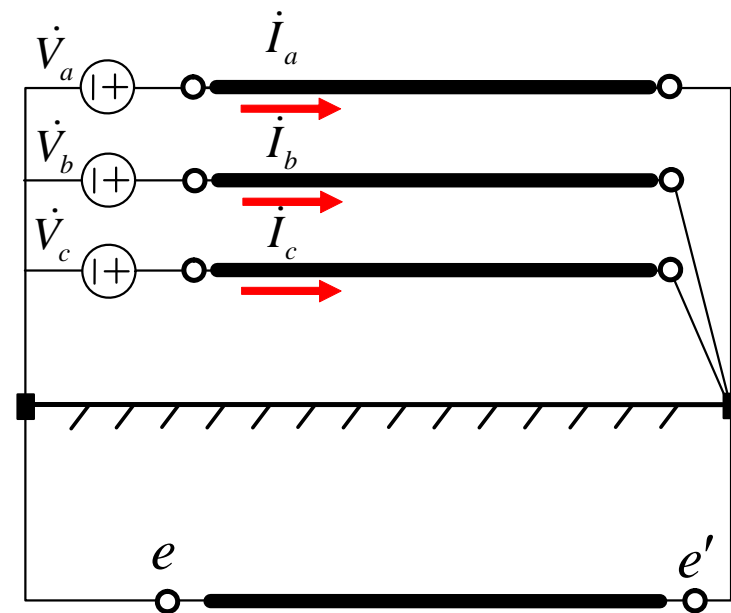
$$\dot{V}_{a(2)} = (z_s - z_m) \dot{I}_{a(2)}$$

$$\dot{V}_{a(0)} = (z_s + 2z_m) \dot{I}_{a(0)}$$

$$z_{(1)} = z_s - z_m$$

$$z_{(2)} = z_s - z_m$$

$$z_{(0)} = z_s + 2z_m$$



$$\{L_S\}_{\text{H/m}} = L_a + L_e - 2M_{ae}$$

$$\{z_S\}_{\Omega/\text{km}} = r_a + r_e + j\omega L_S$$

# 7-4 架空输电线的零序阻抗及其等值电路

## 3. 三相输电线路的零序阻抗

$$\dot{V}_a = z_s \dot{I}_a + z_m \dot{I}_b + z_m \dot{I}_c$$

$$\dot{V}_{a(1)} = (z_s - z_m) \dot{I}_{a(1)}$$

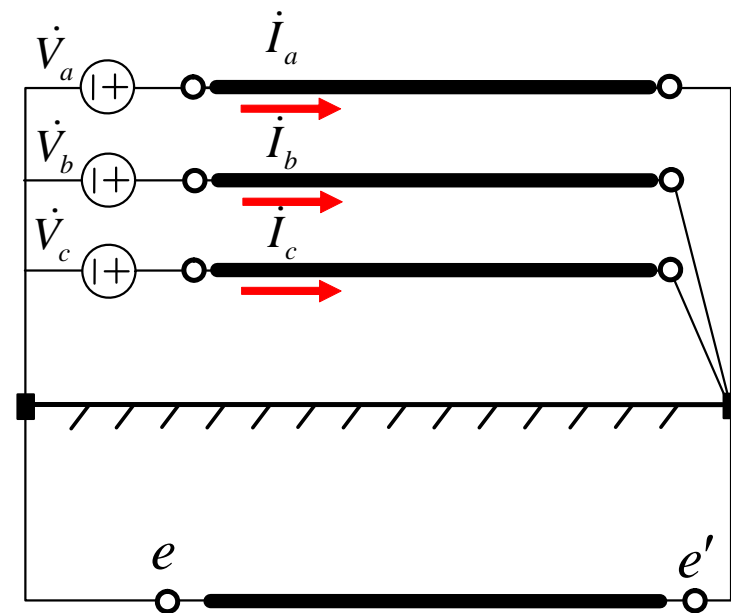
$$\dot{V}_{a(2)} = (z_s - z_m) \dot{I}_{a(2)}$$

$$\dot{V}_{a(0)} = (z_s + 2z_m) \dot{I}_{a(0)}$$

$$z_{(1)} = z_s - z_m$$

$$z_{(2)} = z_s - z_m$$

$$z_{(0)} = z_s + 2z_m$$



$$\{L_S\}_{\text{H/m}} = L_a + L_e - 2M_{ae}$$

$$\{z_S\}_{\Omega/\text{km}} = r_a + r_e + j\omega L_S$$

$$\{z_m\}_{\Omega/\text{km}} = r_e + j\omega (M_{ab} - M_{be} - M_{ae} + L_e)$$

# 7-4 架空输电线的零序阻抗及其等值电路

## 3. 三相输电线路的零序阻抗

$$\dot{V}_a = z_s \dot{I}_a + z_m \dot{I}_b + z_m \dot{I}_c$$

$$\dot{V}_{a(1)} = (z_s - z_m) \dot{I}_{a(1)}$$

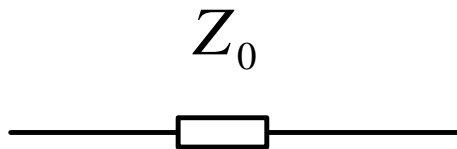
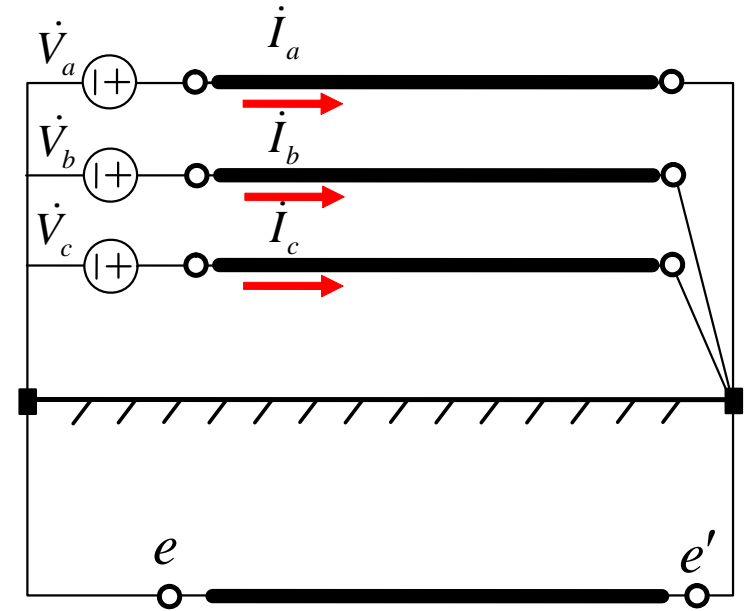
$$\dot{V}_{a(2)} = (z_s - z_m) \dot{I}_{a(2)}$$

$$\dot{V}_{a(0)} = (z_s + 2z_m) \dot{I}_{a(0)}$$

$$z_{(1)} = z_s - z_m$$

$$z_{(2)} = z_s - z_m$$

$$z_{(0)} = z_s + 2z_m$$



$$\{z_{(0)}\}_{\Omega/\text{km}} = r_a + 3r_e + j0.4335 \lg \frac{D_e}{D_{ST}}$$

$$\{z_s\}_{\Omega/\text{km}} = r_a + r_e + j\omega L_s$$

$$\{z_m\}_{\Omega/\text{km}} = r_e + j\omega (M_{ab} - M_{be} - M_{ae} + L_e)$$

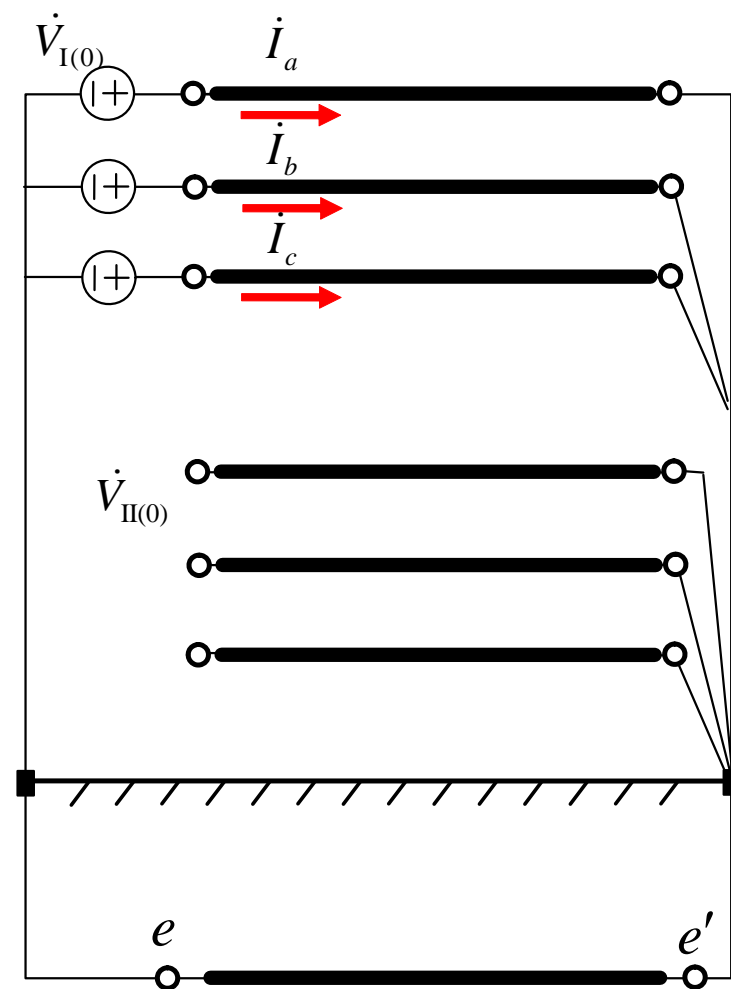
## 7-4 架空输电线的零序阻抗及其等值电路

### 4. 平行架设双回输电线路的零序阻抗及等值电路

#### (1) 线路零序参数

$$\left\{ z_{I(0)} \right\}_{\Omega/\text{km}} = r_a + 3r_e + j0.4335 \lg \frac{D_e}{D_{ST}}$$

互阻抗的求法 $Z_{I-II(0)}$ : I回输电线路三相通过单位零序电流 $i_{I(0)}$ , 在II回每相产生的电压降落在数值上即为 $Z_{I-II(0)}$



# 7-4 架空输电线的零序阻抗及其等值电路

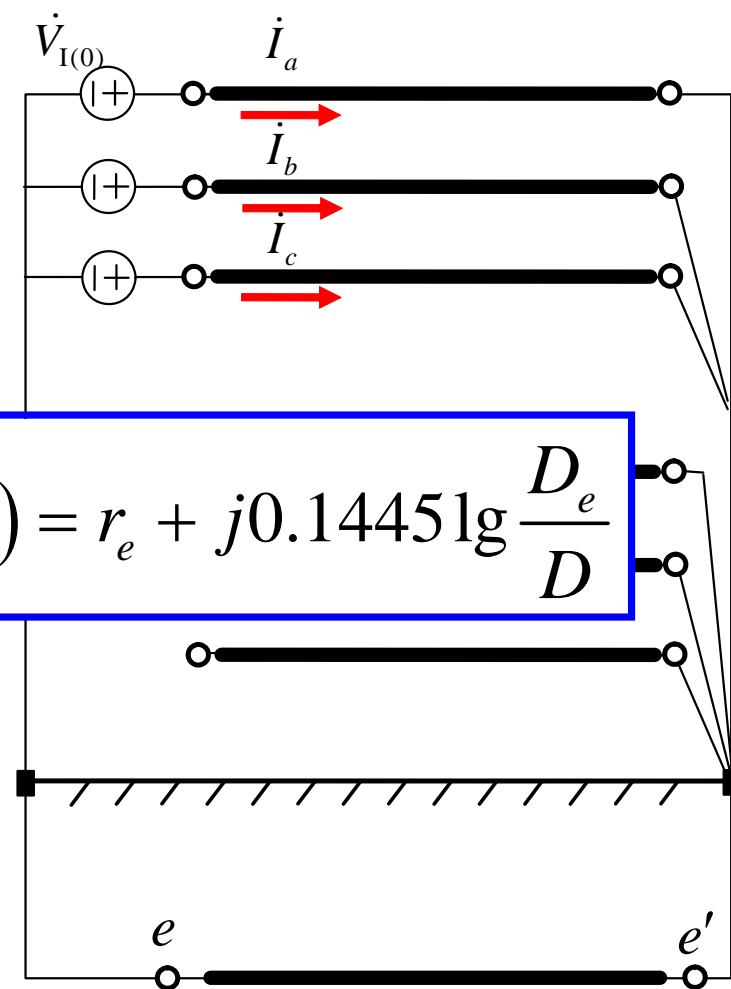
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (1) 线路零序参数

$$\left\{ z_{I(0)} \right\}_{\Omega/\text{km}} = r_a + 3r_e + j0.4335 \lg \frac{D_e}{D_{ST}}$$

$$\left\{ z_m \right\}_{\Omega/\text{km}} = r_e + j\omega \left( M_{ab} - M_{be} - M_{ae} + L_e \right) = r_e + j0.1445 \lg \frac{D_e}{D}$$

互阻抗的求法 $Z_{I-II(0)}$ : I回输电线路三相通过单位零序电流 $i_{I(0)}$ , 在II回每相产生的电压降落在数值上即为 $Z_{I-II(0)}$



## 7-4 架空输电线的零序阻抗及其等值电路

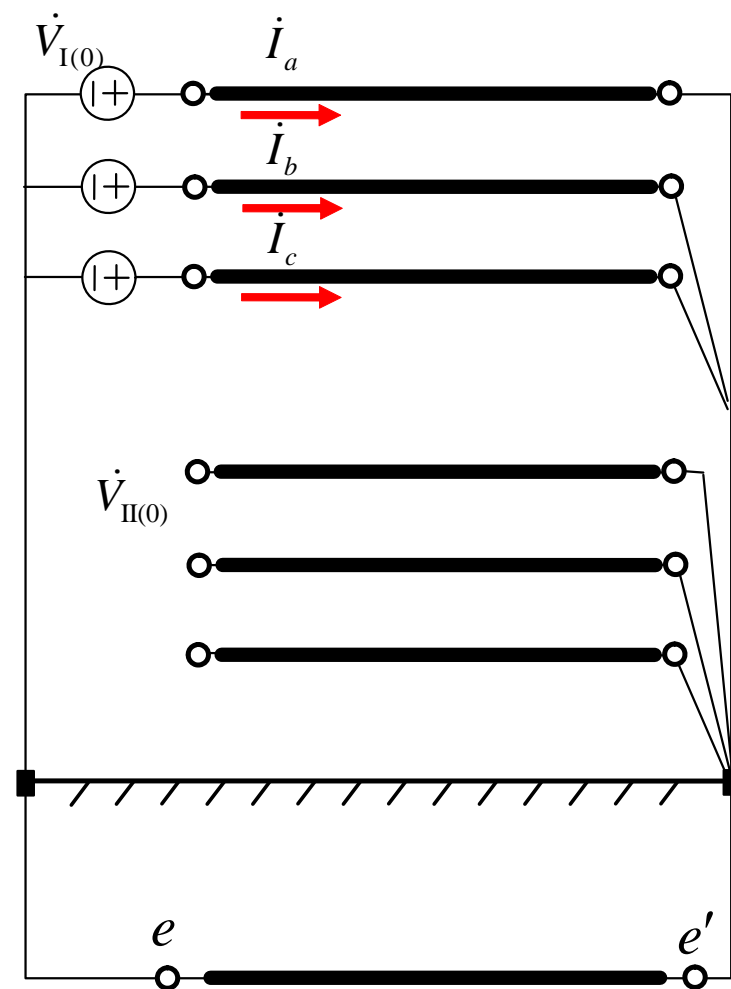
### 4. 平行架设双回输电线路的零序阻抗及等值电路

#### (1) 线路零序参数

$$\left\{ z_{I(0)} \right\}_{\Omega/\text{km}} = r_a + 3r_e + j0.4335 \lg \frac{D_e}{D_{ST}}$$

$$\left\{ z_{I-II(0)} \right\}_{\Omega/\text{km}} = 3 \left[ r_e + j0.1445 \lg \frac{D_e}{D_{I-II}} \right]$$

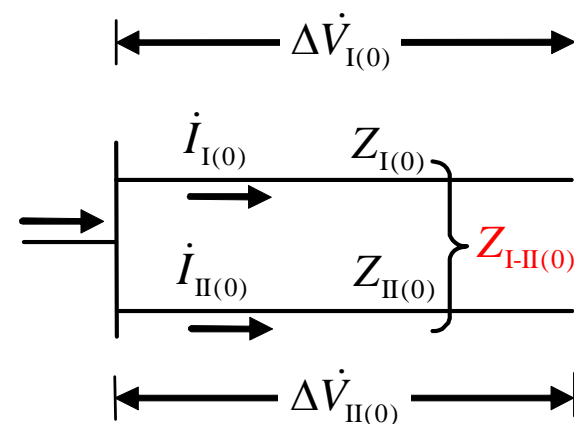
互阻抗的求法 $Z_{I-II(0)}$ : I回输电线路三相通过单位零序电流 $i_{I(0)}$ , 在II回每相产生的电压降落在数值上即为 $Z_{I-II(0)}$



## 7-4 架空输电线的零序阻抗及其等值电路

### 4. 平行架设双回输电线路的零序阻抗及等值电路

#### (2) 平行架设双回输电线路的零序等值电路(首端相连)



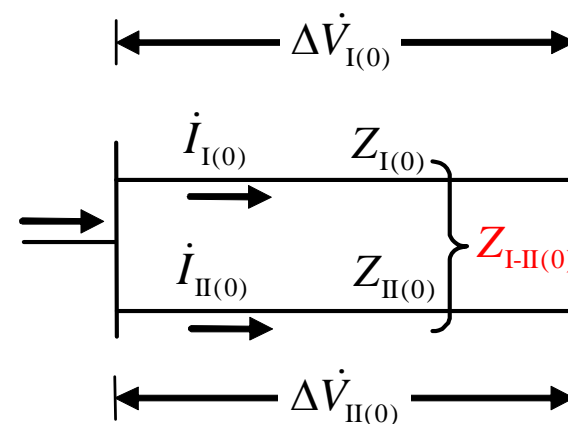
## 7-4 架空输电线的零序阻抗及其等值电路

### 4. 平行架设双回输电线路的零序阻抗及等值电路

#### (2) 平行架设双回输电线路的零序等值电路 (首端相连)

$$\dot{V}_{I(0)} = Z_{I(0)} \dot{I}_{I(0)} + Z_{I-II(0)} \dot{I}_{II(0)}$$

$$\dot{V}_{II(0)} = Z_{I-II(0)} \dot{I}_{I(0)} + Z_{II(0)} \dot{I}_{II(0)}$$





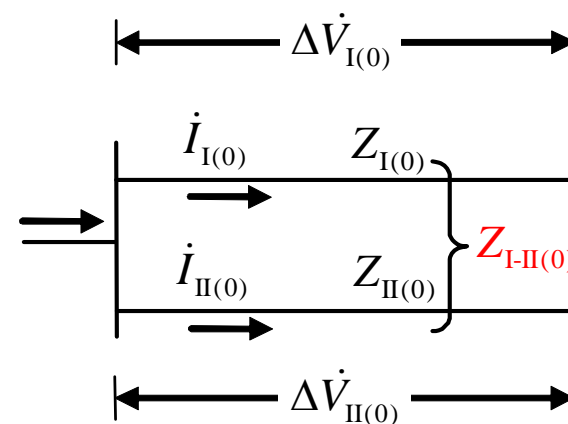
## 7-4 架空输电线的零序阻抗及其等值电路

### 4. 平行架设双回输电线路的零序阻抗及等值电路

#### (2) 平行架设双回输电线路的零序等值电路 (首端相连)

$$\dot{V}_{I(0)} = Z_{I(0)} \dot{I}_{I(0)} + Z_{I-II(0)} \dot{I}_{II(0)}$$

$$\dot{V}_{II(0)} = Z_{I-II(0)} \dot{I}_{I(0)} + Z_{II(0)} \dot{I}_{II(0)}$$



$$\dot{V}_{I(0)} = Z_{I-II(0)} (\dot{I}_{I(0)} + \dot{I}_{II(0)}) + (Z_{I(0)} - Z_{I-II(0)}) \dot{I}_{I(0)}$$

$$\dot{V}_{II(0)} = Z_{I-II(0)} (\dot{I}_{I(0)} + \dot{I}_{II(0)}) + (Z_{II(0)} - Z_{I-II(0)}) \dot{I}_{II(0)}$$

# 7-4 架空输电线的零序阻抗及其等值电路

## 4. 平行架设双回输电线路的零序阻抗及等值电路

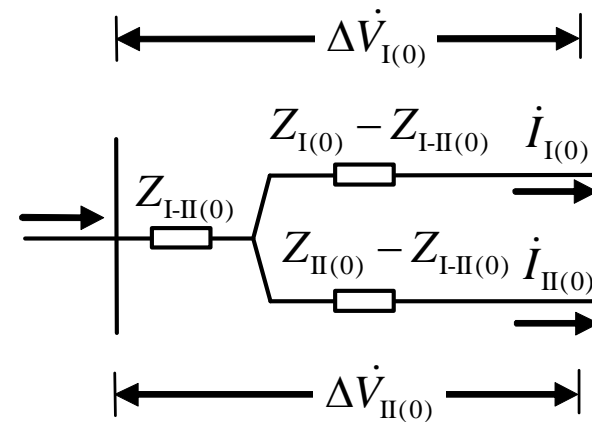
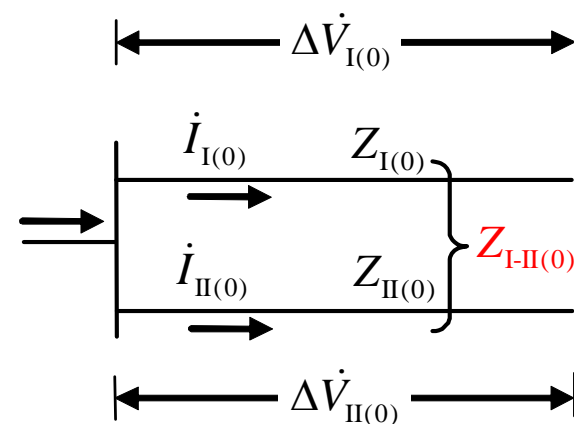
### (2) 平行架设双回输电线路的零序等值电路 (首端相连)

$$\dot{V}_{I(0)} = Z_{I(0)} \dot{I}_{I(0)} + Z_{I-II(0)} \dot{I}_{II(0)}$$

$$\dot{V}_{II(0)} = Z_{I-II(0)} \dot{I}_{I(0)} + Z_{II(0)} \dot{I}_{II(0)}$$

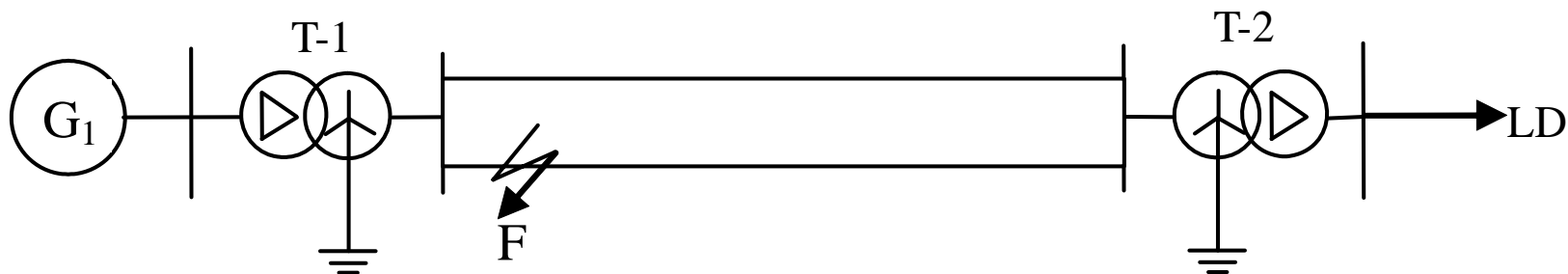
$$\dot{V}_{I(0)} = Z_{I-II(0)} (\dot{I}_{I(0)} + \dot{I}_{II(0)}) + (Z_{I(0)} - Z_{I-II(0)}) \dot{I}_{I(0)}$$

$$\dot{V}_{II(0)} = Z_{I-II(0)} (\dot{I}_{I(0)} + \dot{I}_{II(0)}) + (Z_{II(0)} - Z_{I-II(0)}) \dot{I}_{II(0)}$$



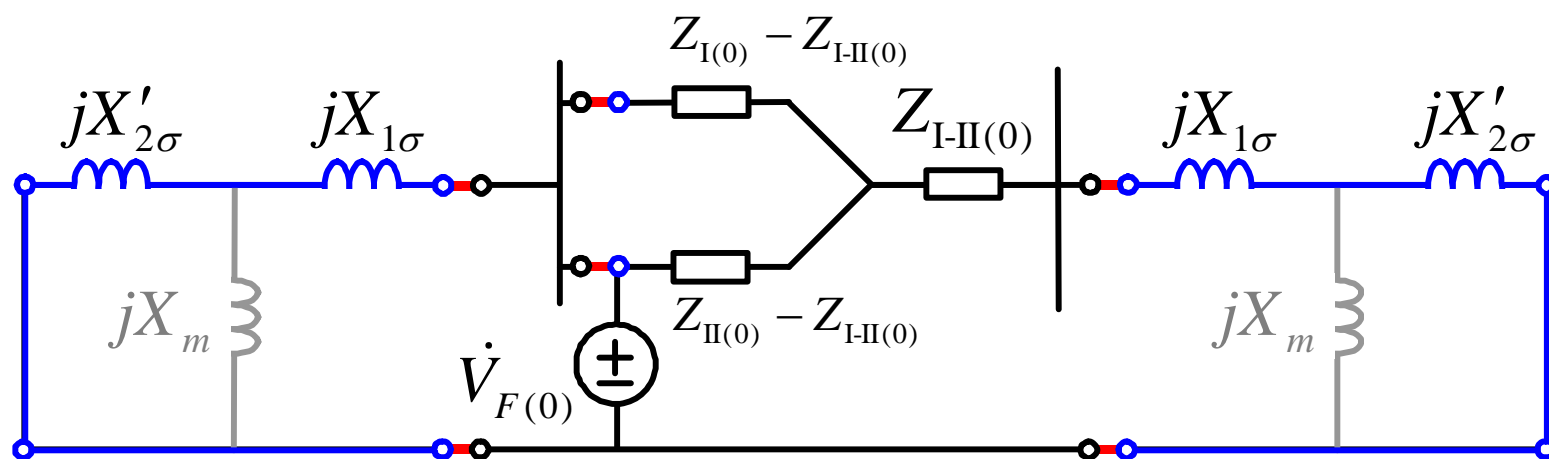
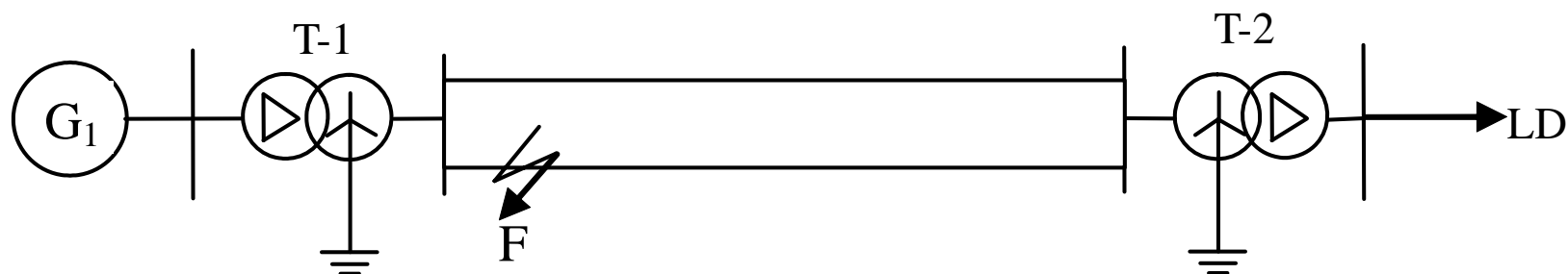
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (2) 平行架设双回输电线路的零序等值电路——应用举例



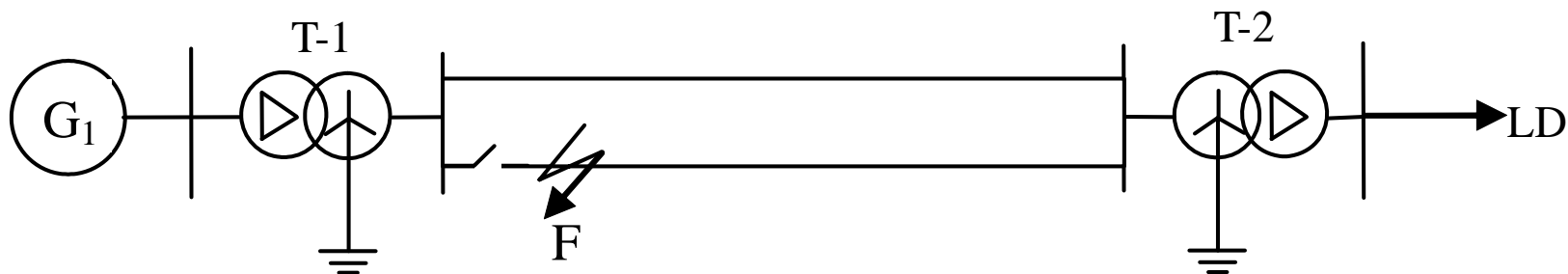
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (2) 平行架设双回输电线路的零序等值电路——应用举例



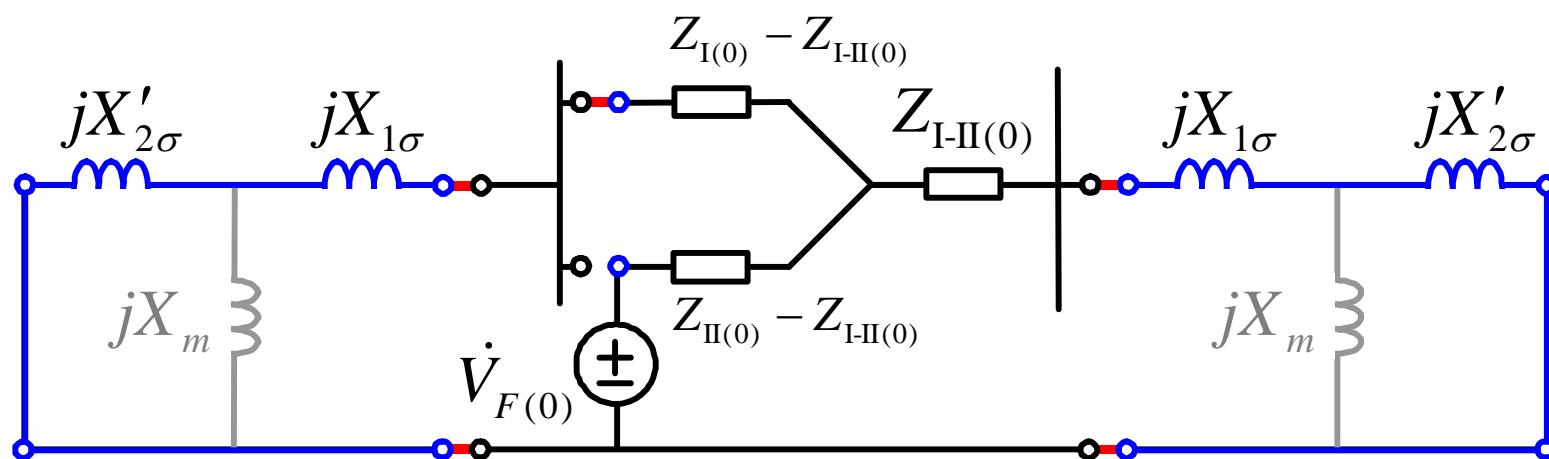
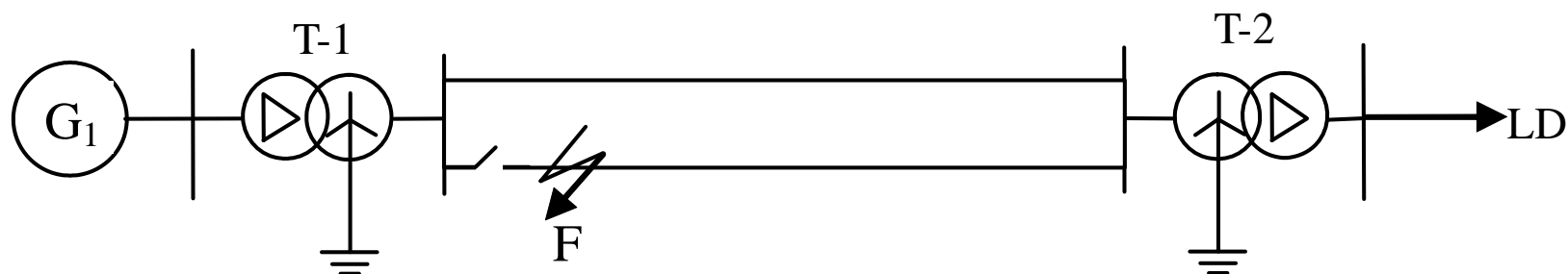
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (2) 平行架设双回输电线路的零序等值电路——应用举例



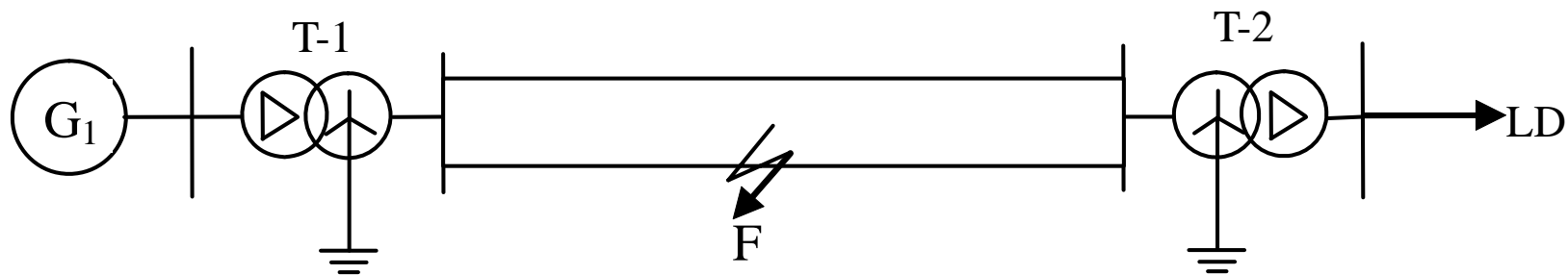
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (2) 平行架设双回输电线路的零序等值电路——应用举例



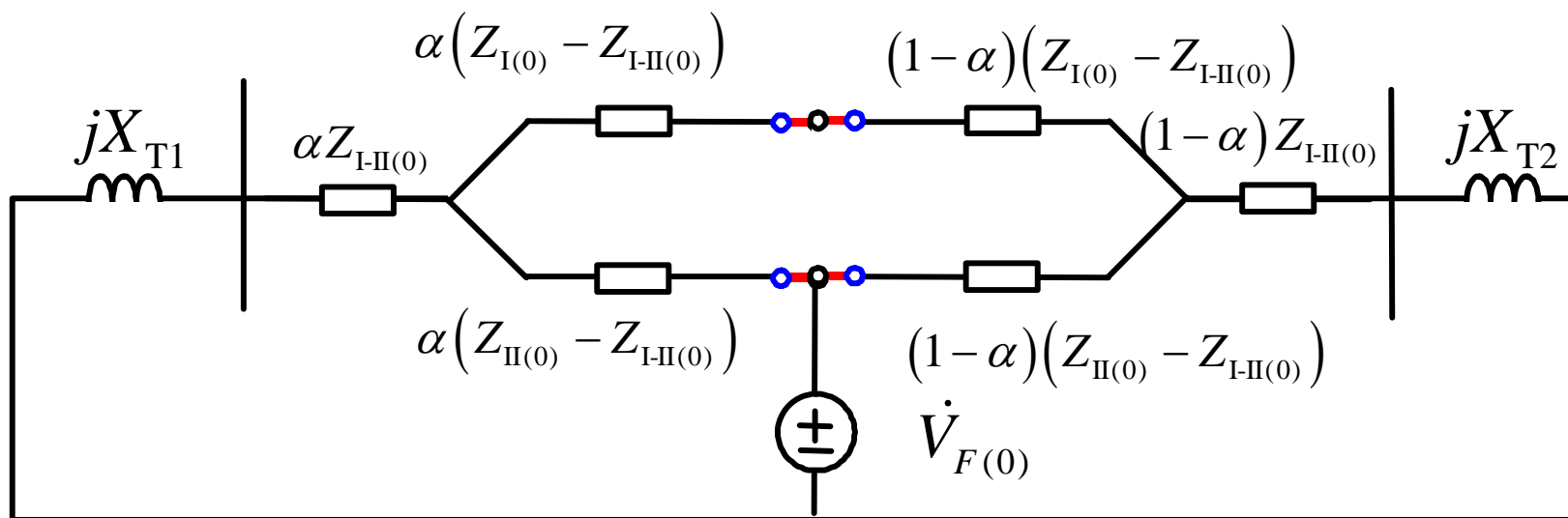
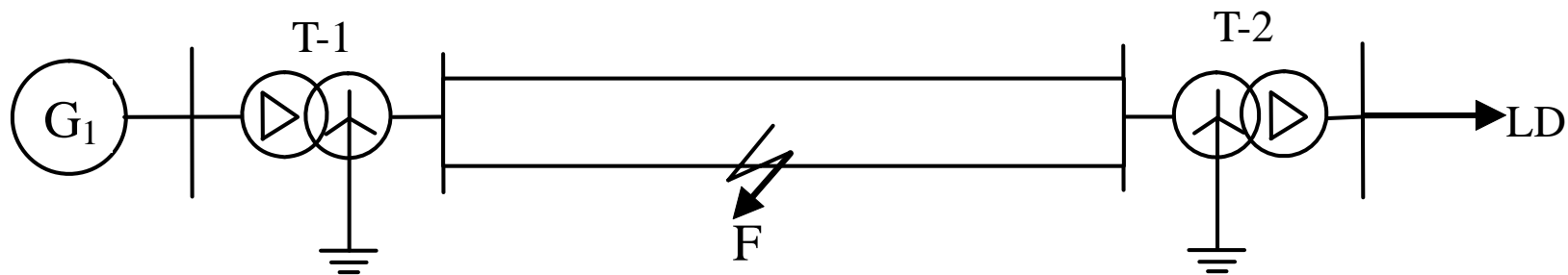
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (2) 平行架设双回输电线路的零序等值电路——应用举例



## 4. 平行架设双回输电线路的零序阻抗及等值电路

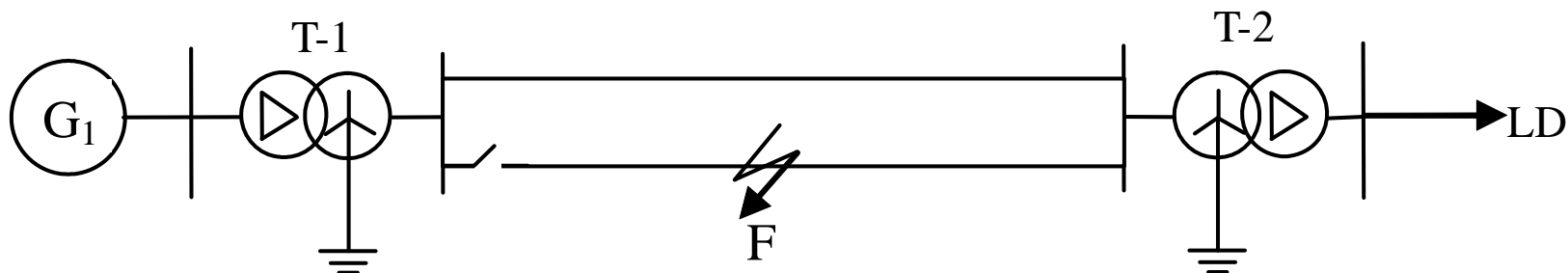
### (2) 平行架设双回输电线路的零序等值电路——应用举例





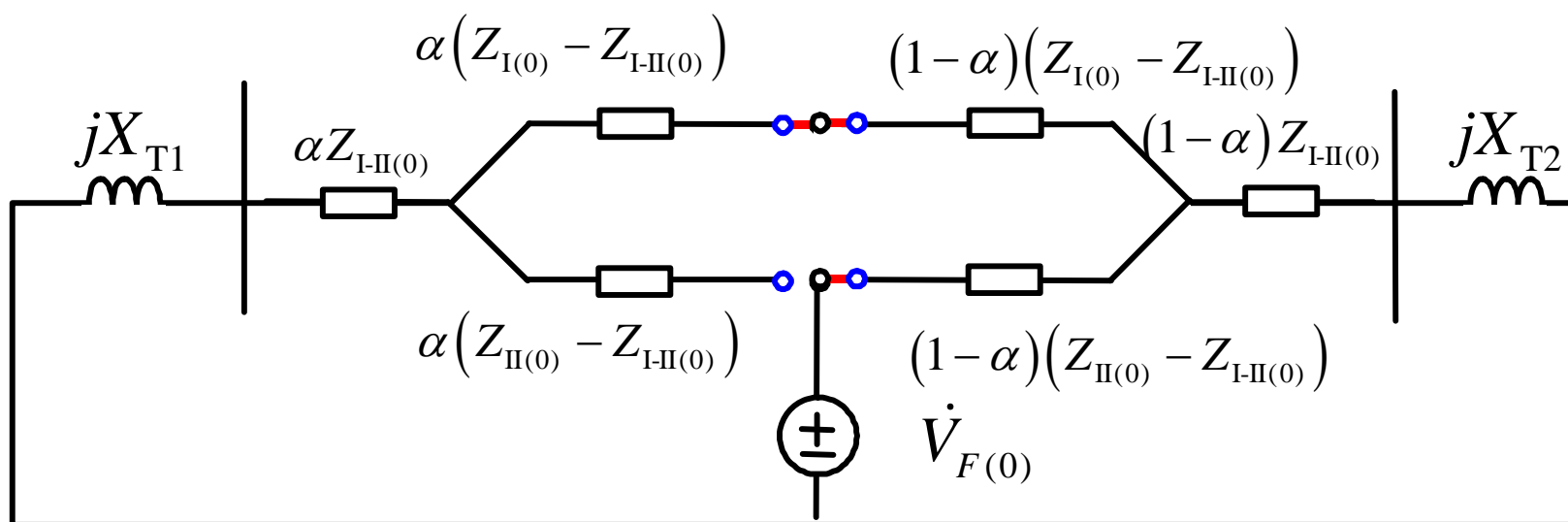
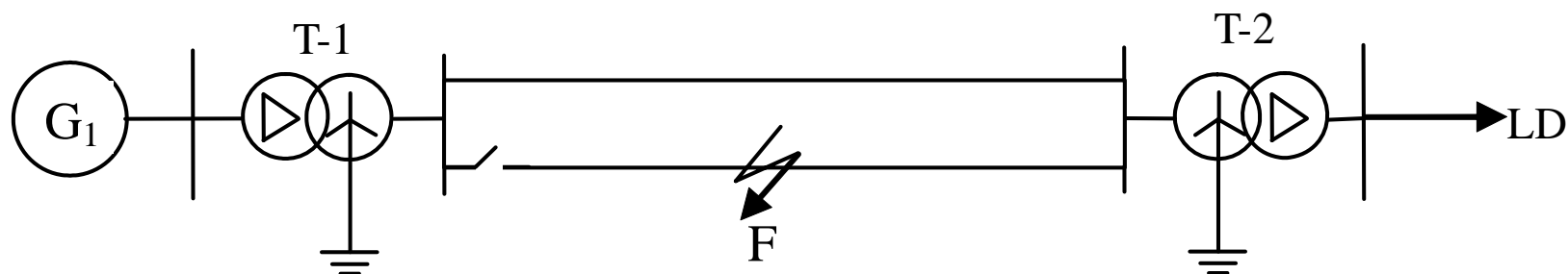
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (2) 平行架设双回输电线路的零序等值电路——应用举例



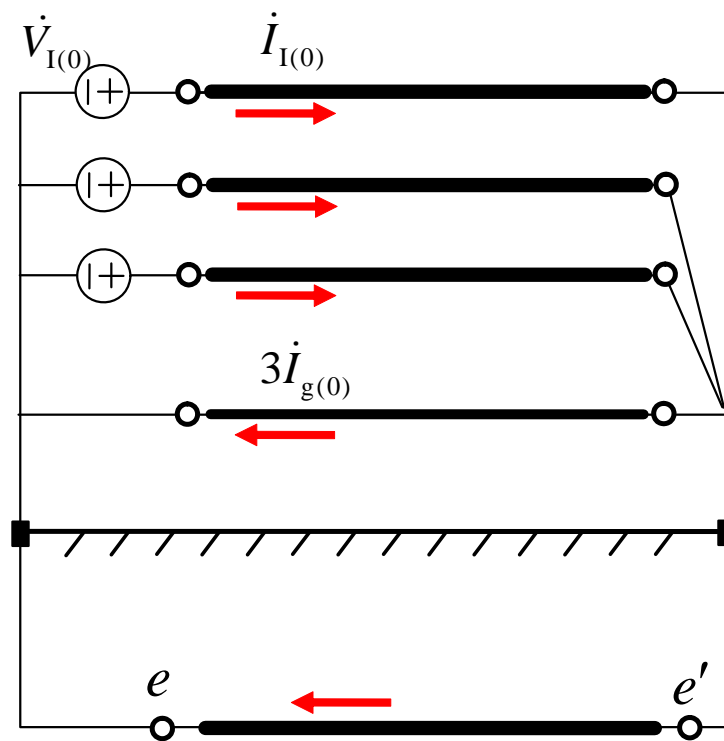
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (2) 平行架设双回输电线路的零序等值电路——应用举例



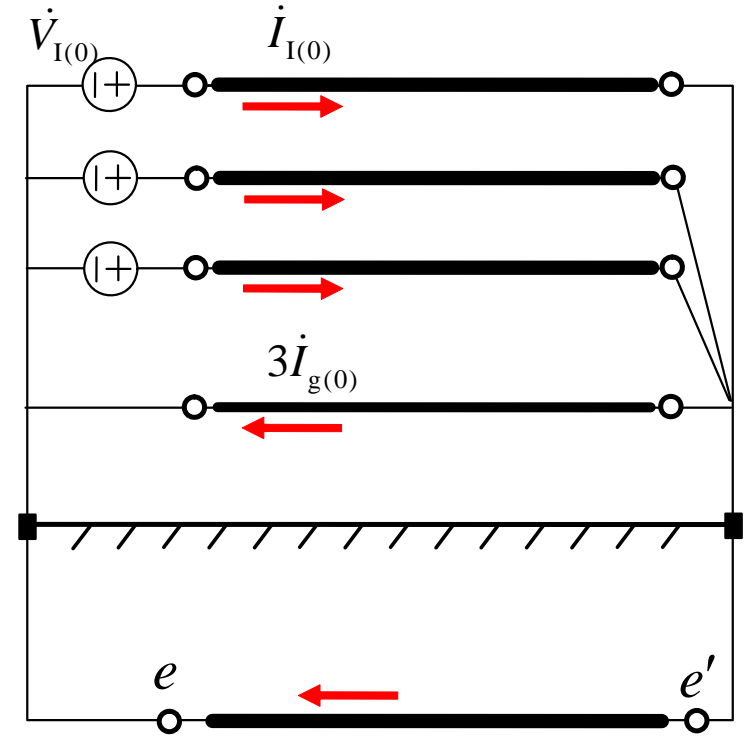
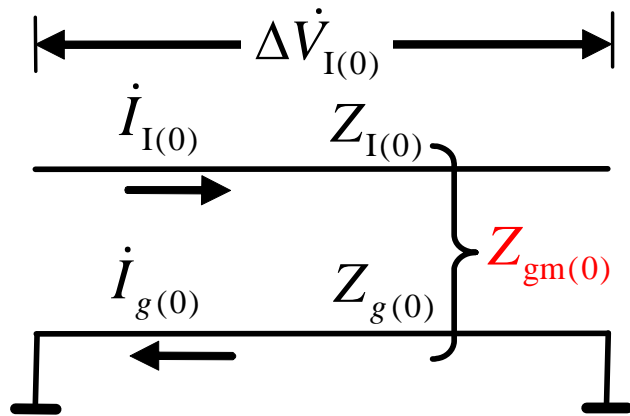
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (3) 有架空地线的单回输电线路的零序等值电路



# 4. 平行架设双回输电线路的零序阻抗及等值电路

## (3) 有架空地线的单回输电线路的零序等值电路

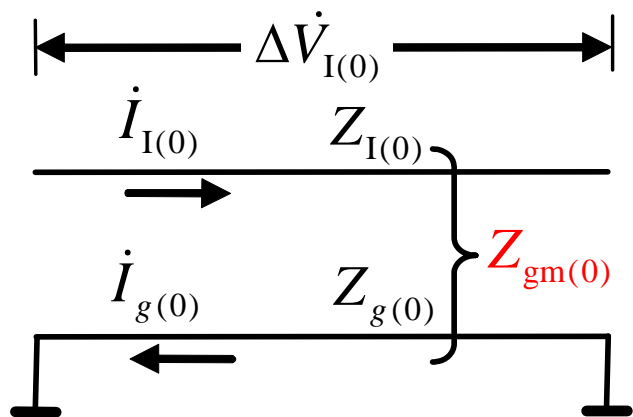
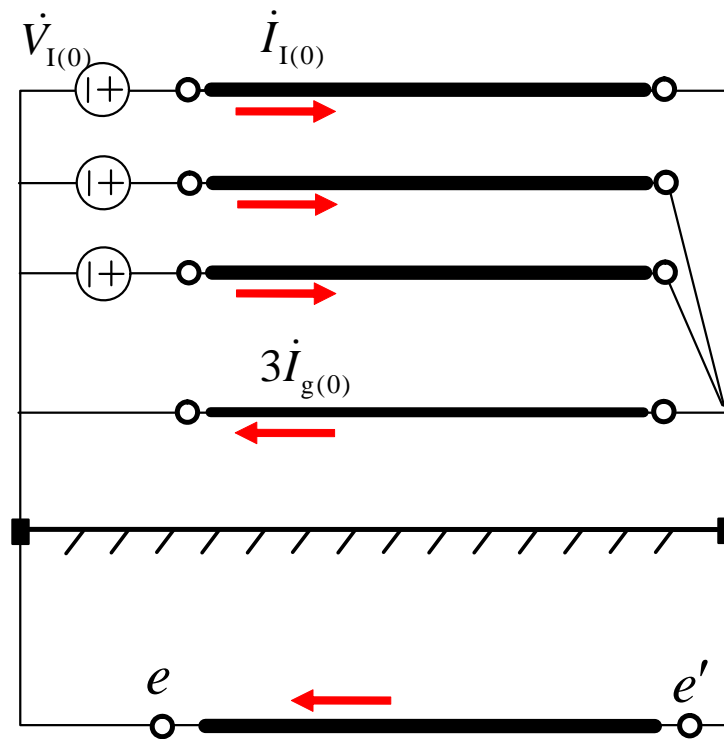


## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (3) 有架空地线的单回输电线路的零序等值电路

$$\Delta \dot{V}_{I(0)} = Z_{I(0)} \dot{I}_{I(0)} - Z_{gm(0)} \dot{I}_{g(0)}$$

$$0 = Z_{g(0)} \dot{I}_{g(0)} - Z_{gm(0)} \dot{I}_{I(0)}$$



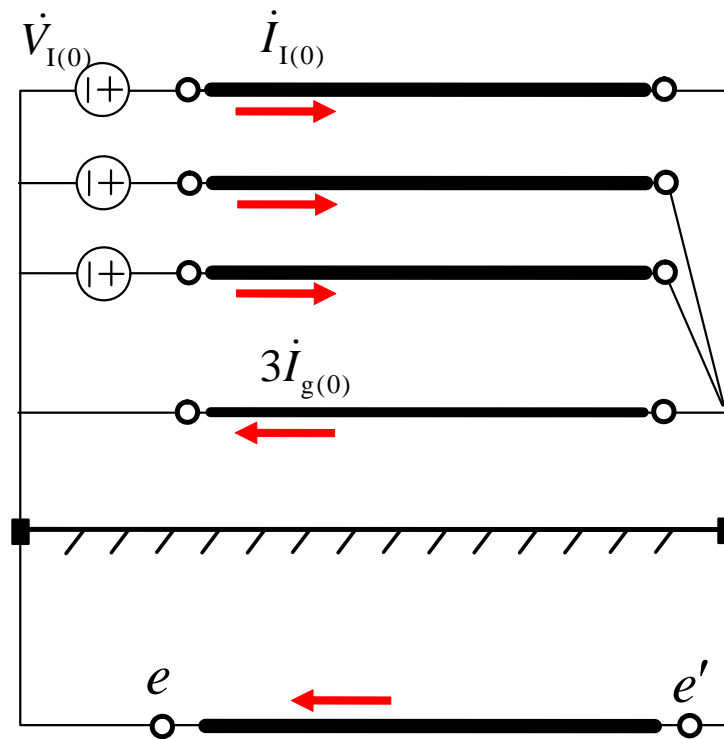
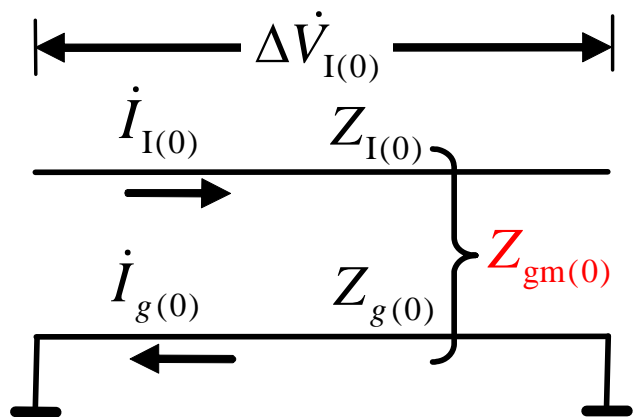
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$$\dot{V}_{I(0)} = \left( Z_{I(0)} - \frac{Z_{gm(0)}^2}{Z_{g(0)}} \right) \dot{I}_{I(0)}$$



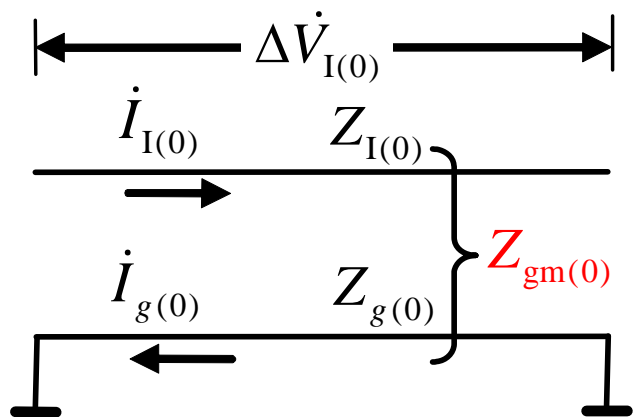
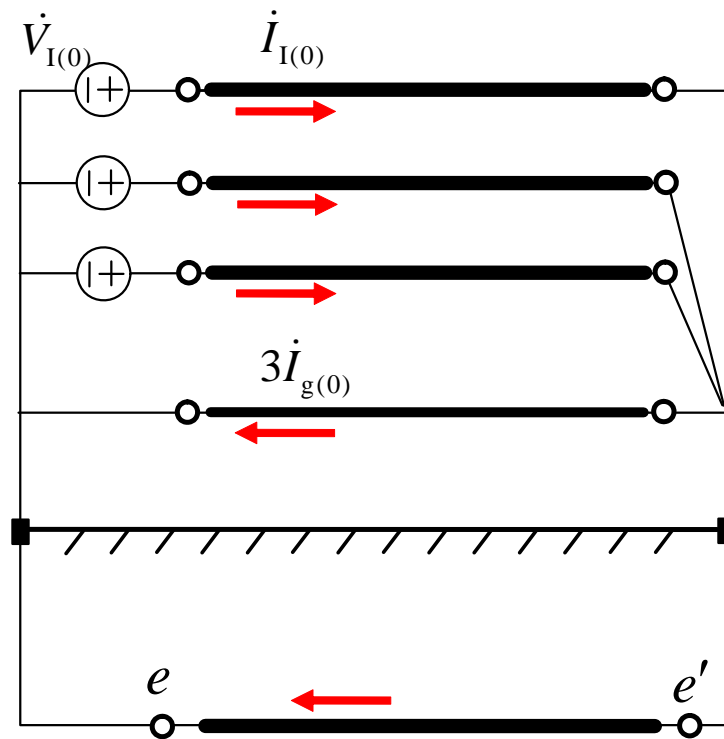
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### (3) 有架空地线的单回输电线路的零序等值电路

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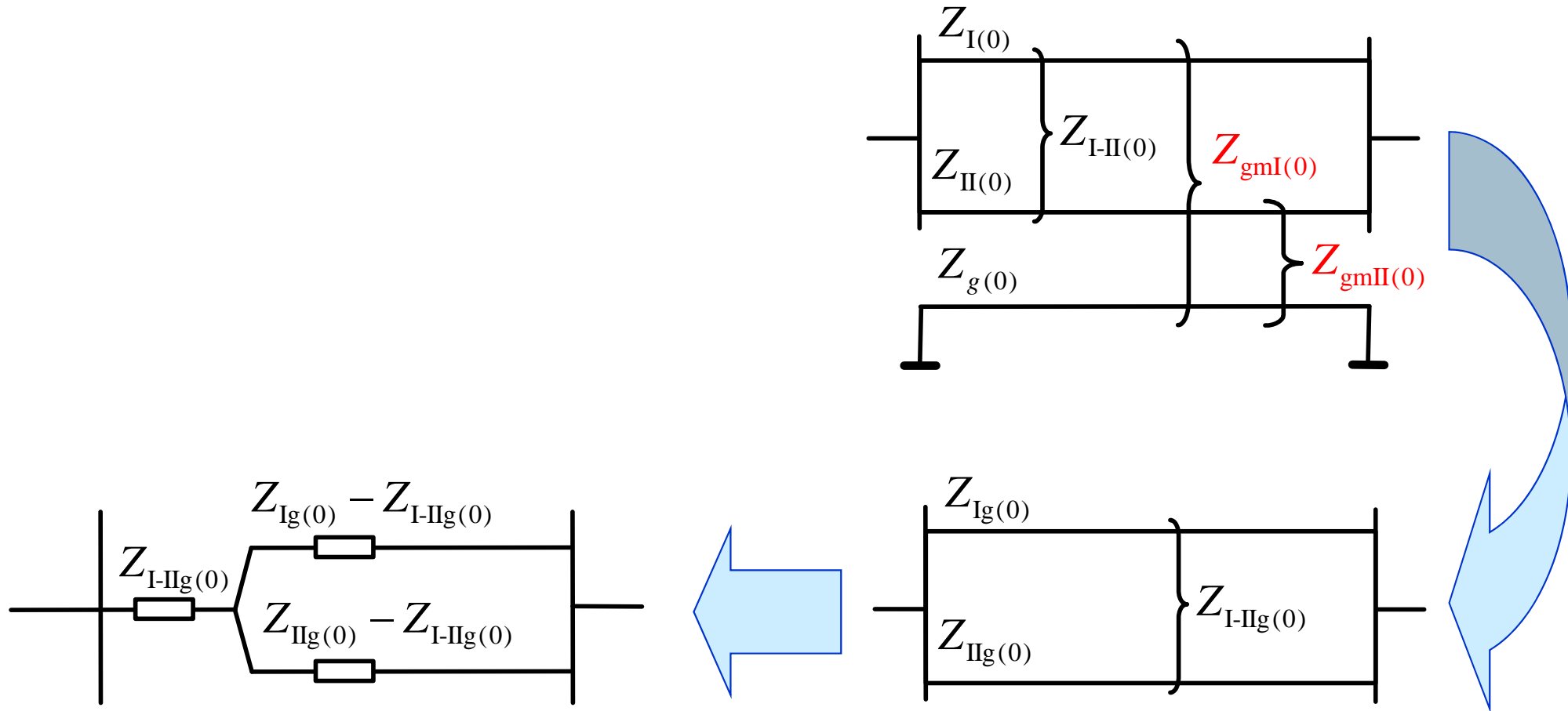
$$\dot{V}_{I(0)} = \left( Z_{I(0)} - \frac{Z_{gm(0)}^2}{Z_{g(0)}} \right) \dot{I}_{I(0)}$$



$$Z_{I(0)} - \frac{Z_{gm(0)}^2}{Z_{g(0)}}$$

## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (3) 有架空地线的双回输电线路的零序等值电路





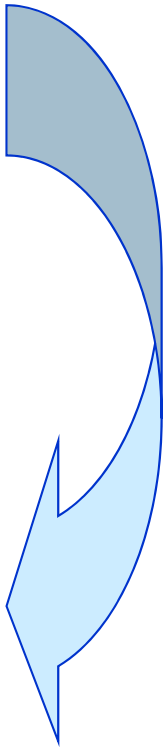
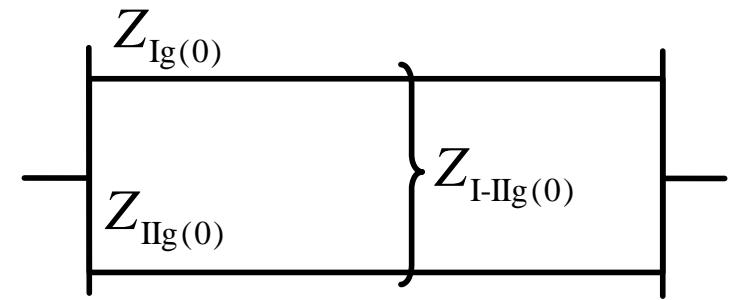
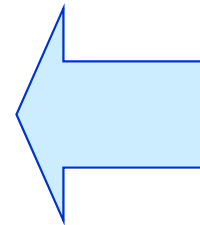
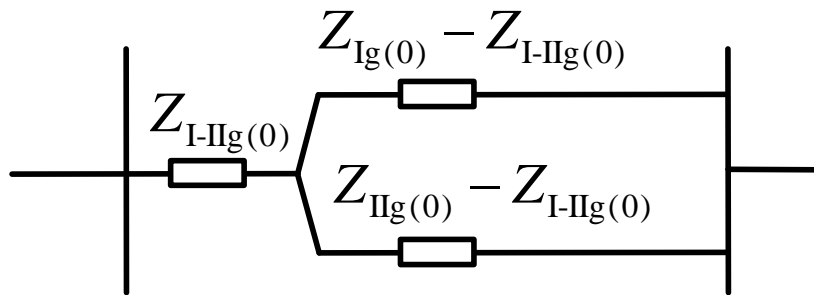
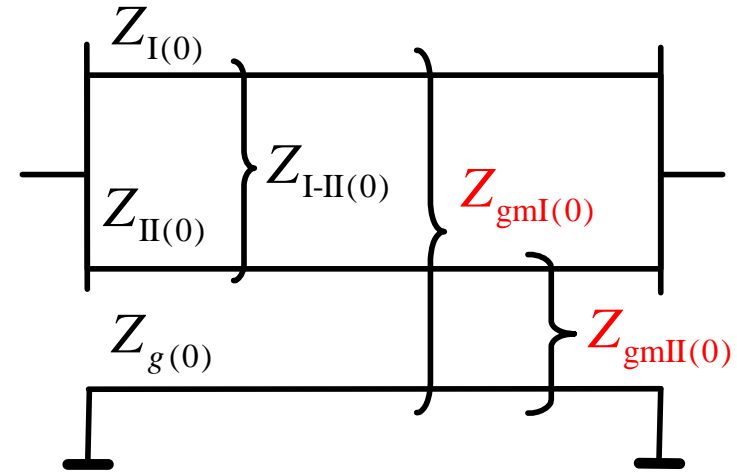
## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (3) 有架空地线的双回输电线路的零序等值电路

$$Z_{Ig(0)} = Z_{I(0)} - Z_{gmI(0)}^2 / Z_g(0)$$

$$Z_{IIg(0)} = Z_{II(0)} - Z_{gmII(0)}^2 / Z_g(0)$$

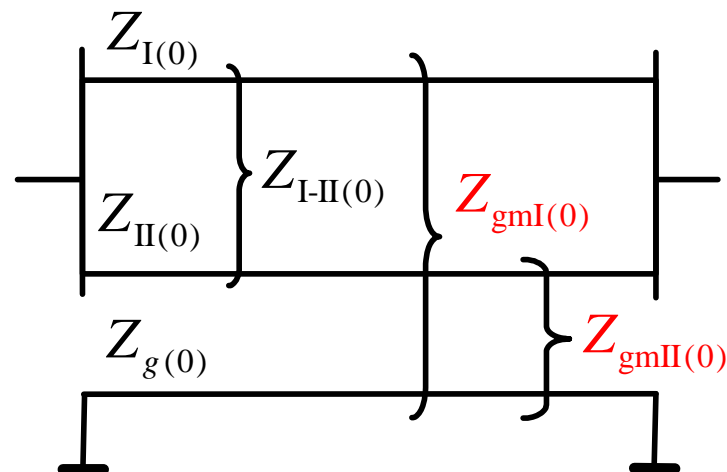
$$Z_{I-IIg(0)} = Z_{I-II(0)} - (Z_{gmI(0)} \times Z_{gmII(0)}) / Z_g(0)$$



## 4. 平行架设双回输电线路的零序阻抗及等值电路

### (3) 有架空地线的双回输电线路的零序等值电路

$$\begin{aligned}\Delta \dot{V}_{I(0)} &= Z_{I(0)} \dot{I}_{I(0)} + Z_{I-II(0)} \dot{I}_{II(0)} - Z_{gmI(0)} \dot{I}_{g(0)} \\ \Delta \dot{V}_{II(0)} &= Z_{II(0)} \dot{I}_{II(0)} + Z_{I-II(0)} \dot{I}_{I(0)} - Z_{gmII(0)} \dot{I}_{g(0)} \\ 0 &= Z_{g(0)} \dot{I}_{g(0)} - Z_{gmI(0)} \dot{I}_{I(0)} - Z_{gmII(0)} \dot{I}_{II(0)}\end{aligned}$$

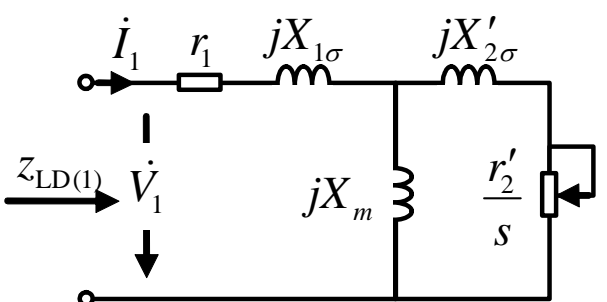
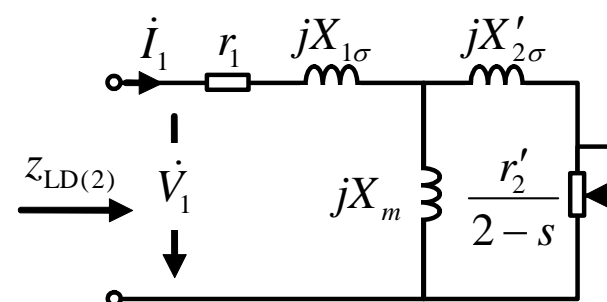
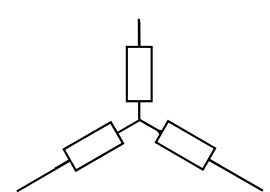


$$\begin{aligned}Z_{gmI(0)} \dot{I}_{g(0)} &= \left( Z_{gmI(0)}^2 / Z_{g(0)} \right) \dot{I}_{I(0)} + \left( Z_{gmI(0)} Z_{gmII(0)} / Z_{g(0)} \right) \dot{I}_{II(0)} \\ Z_{gmII(0)} \dot{I}_{g(0)} &= \left( Z_{gmI(0)} Z_{gmII(0)} / Z_{g(0)} \right) \dot{I}_{I(0)} + \left( Z_{gmII(0)}^2 / Z_{g(0)} \right) \dot{I}_{II(0)}\end{aligned}$$

$$\begin{aligned}\Delta \dot{V}_{I(0)} &= Z_{Ig(0)} \dot{I}_{I(0)} + Z_{I-IIg(0)} \dot{I}_{II(0)} \\ \Delta \dot{V}_{II(0)} &= Z_{IIg(0)} \dot{I}_{II(0)} + Z_{I-IIg(0)} \dot{I}_{I(0)}\end{aligned}$$

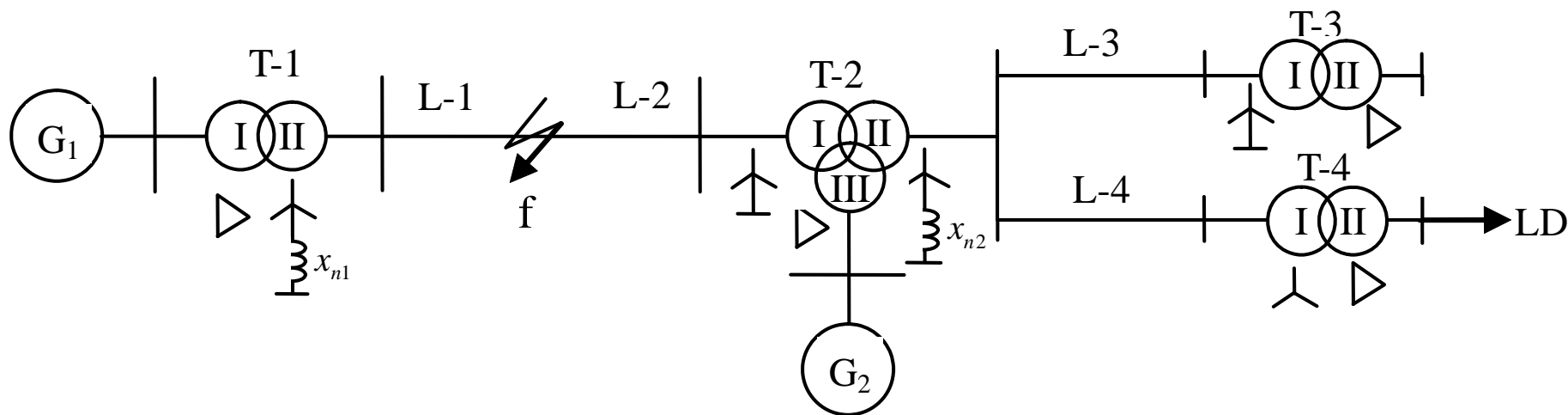
$$\begin{aligned}Z_{Ig(0)} &= Z_{I(0)} - Z_{gmI(0)}^2 / Z_{g(0)} \\ Z_{IIg(0)} &= Z_{II(0)} - Z_{gmII(0)}^2 / Z_{g(0)} \\ Z_{I-IIg(0)} &= Z_{I-II(0)} - \left( Z_{gmI(0)} \times Z_{gmII(0)} \right) / Z_{g(0)}\end{aligned}$$

## 7-6 综合负荷的序阻抗

正序阻抗	负序阻抗	零序阻抗
		
$z_{LD(1)} = \frac{V_{LD}^2}{S_{LD}} (\cos \varphi + j \sin \varphi)$		
$z_{LD(1)} = 0.8 + j0.6$ $z_{LD(1)} = j1.2$	$x_{(2)} = j0.35$	$x_{(0)} = \infty$

## 7-7 电力系统各序网络的制定

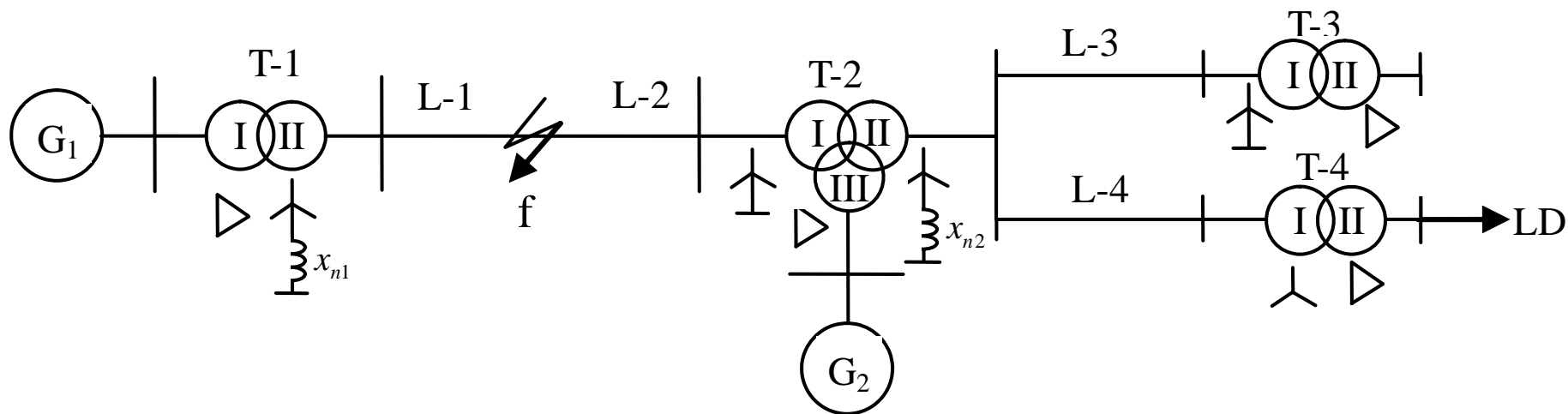
### 算例



- 在故障点分别叠加各序电势，从故障点开始，逐步查明各序电流流通的情况；
- 正序负序看负荷，零序网络看电流。

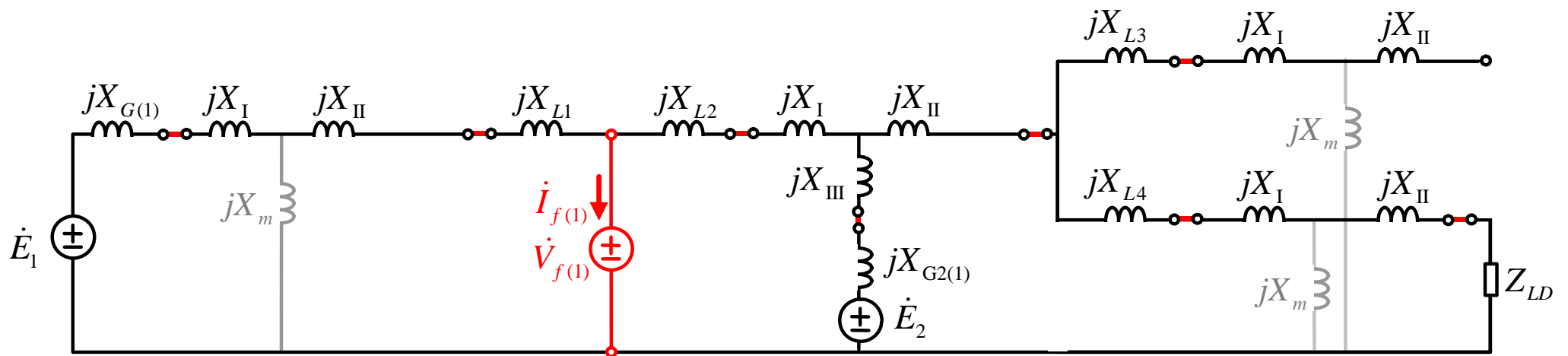
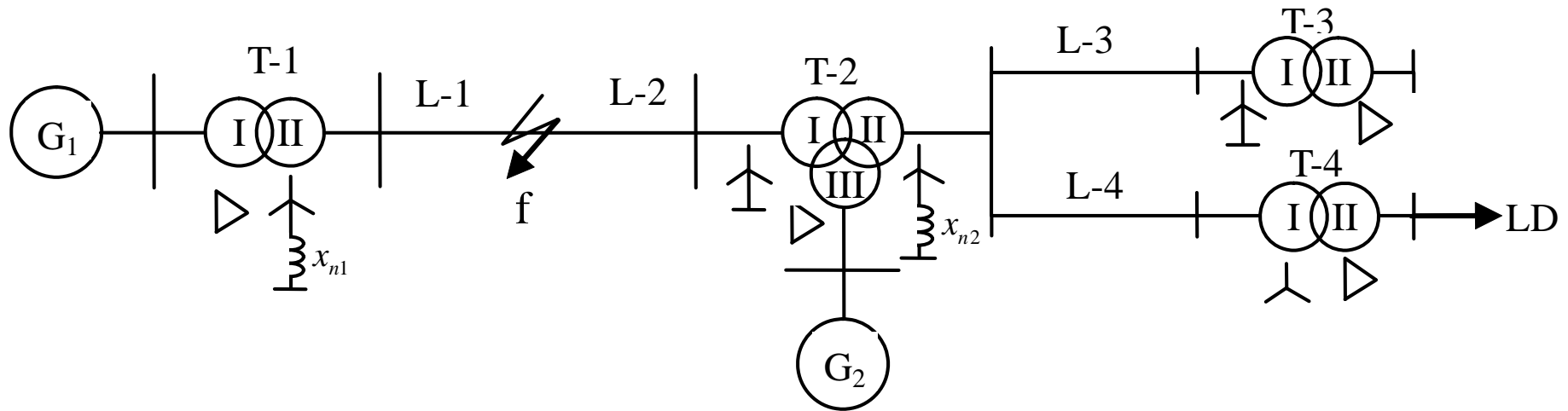
# 7-7 电力系统各序网络的制定

## 算例—正序网络



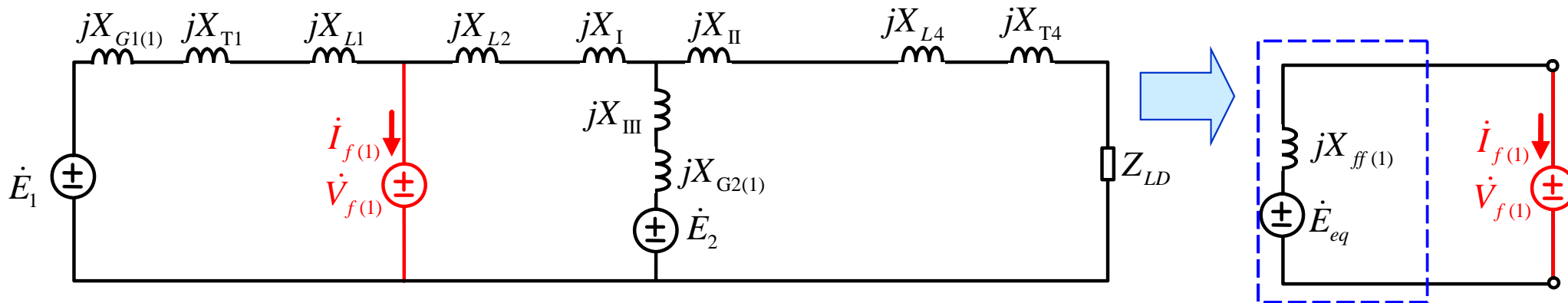
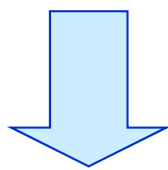
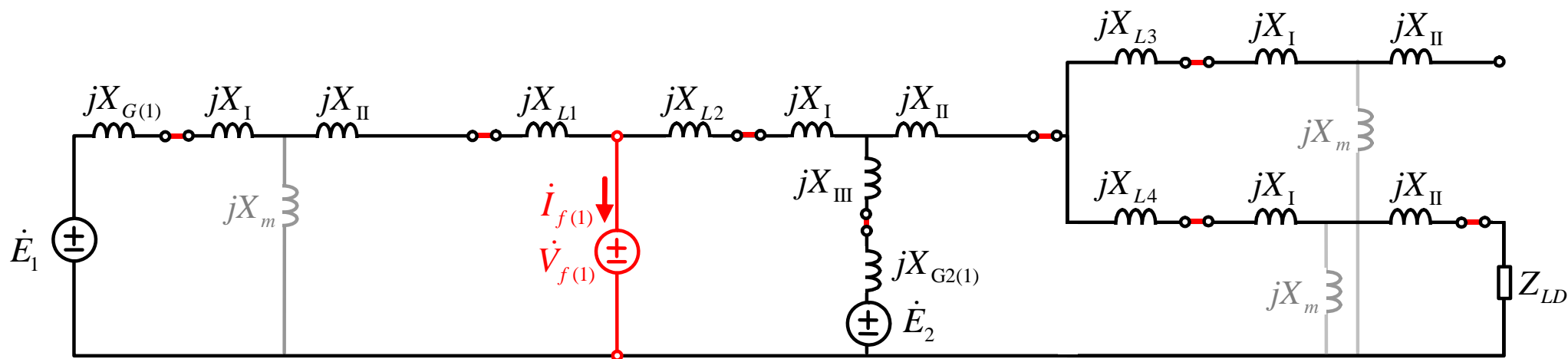
# 7-7 电力系统各序网络的制定

## 算例—正序网络



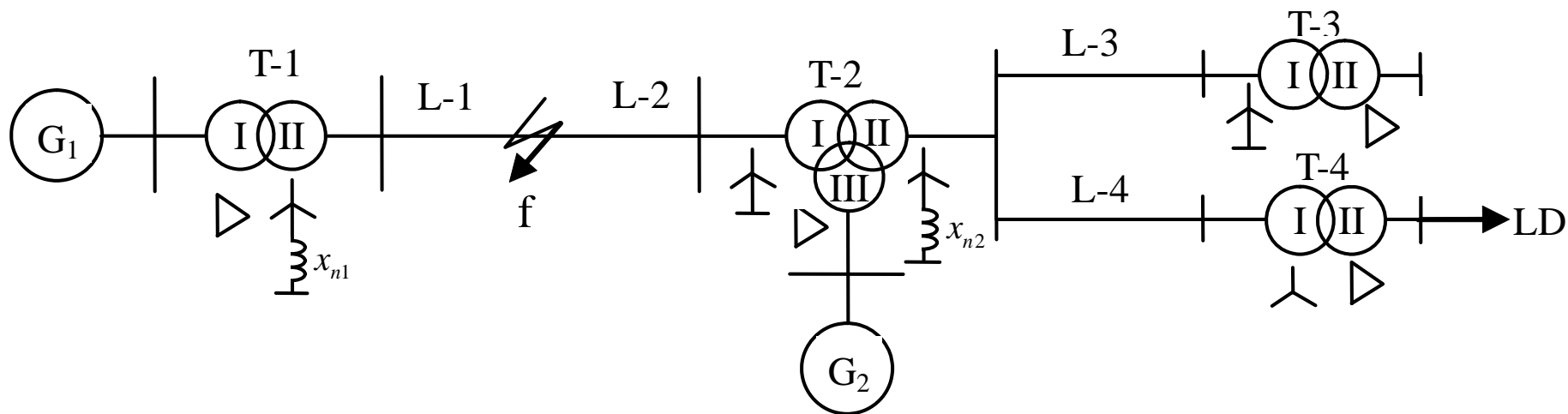
# 7-7 电力系统各序网络的制定

## 算例—正序网络



# 7-7 电力系统各序网络的制定

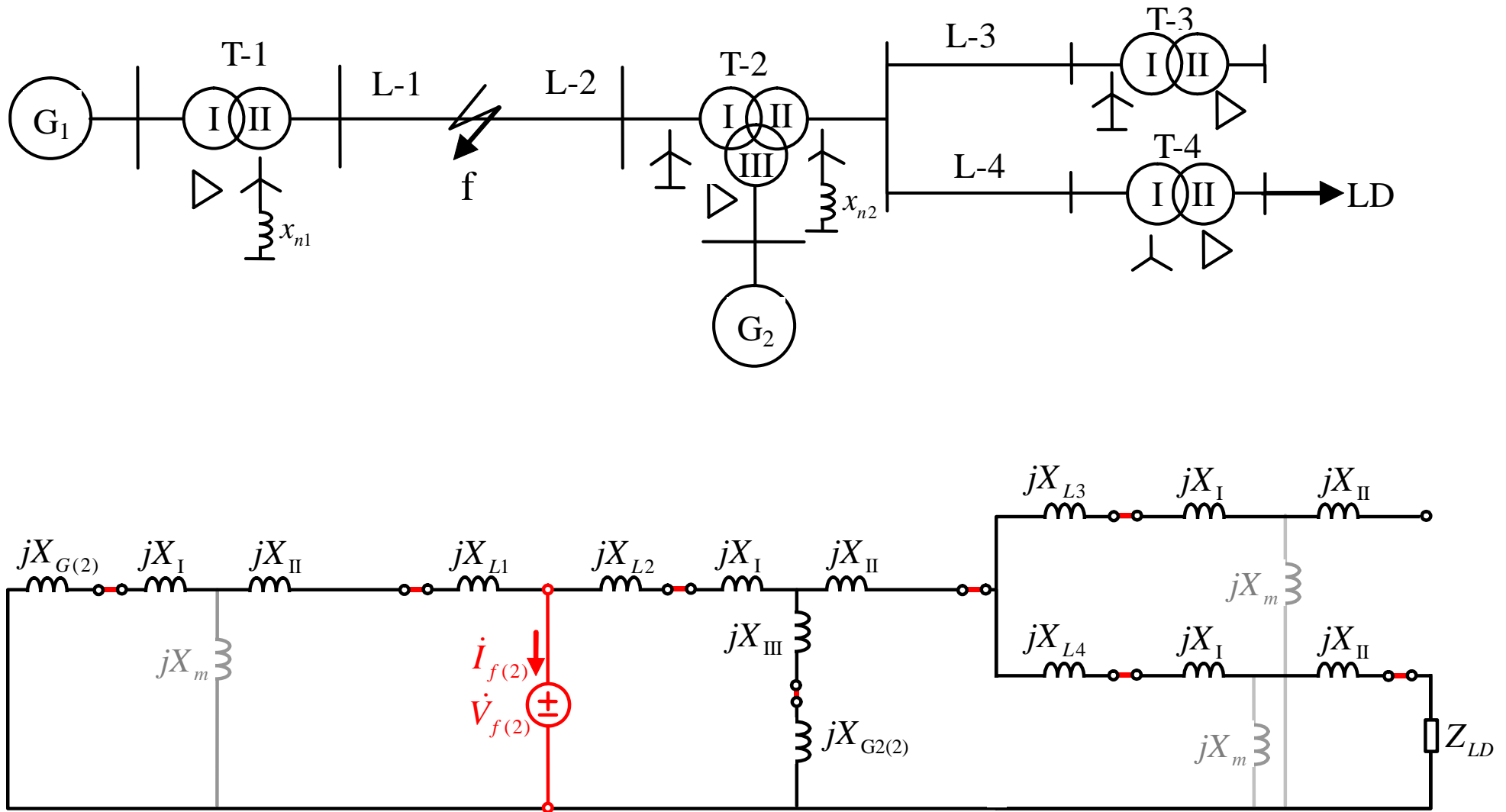
## 算例—负序网络





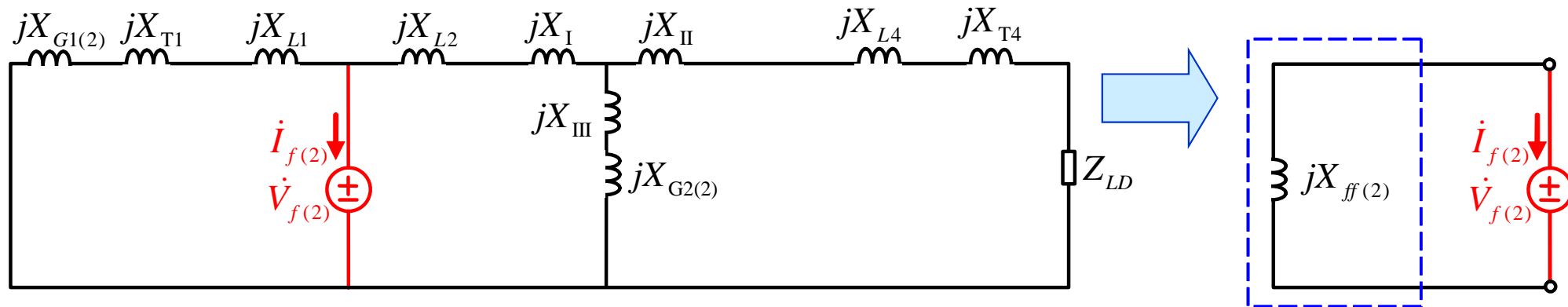
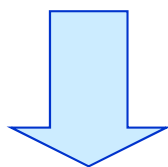
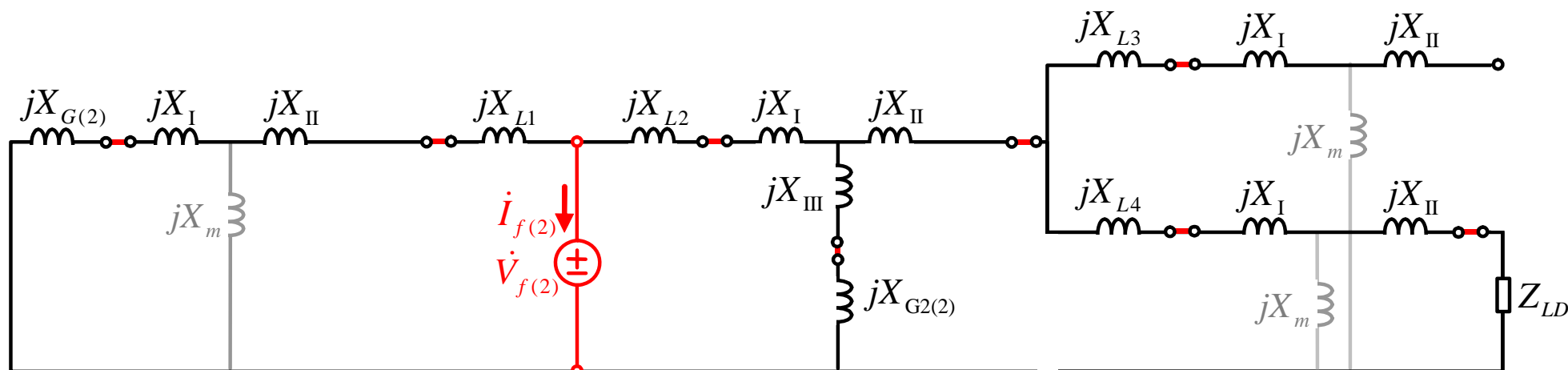
# 7-7 电力系统各序网络的制定

## 算例—负序网络



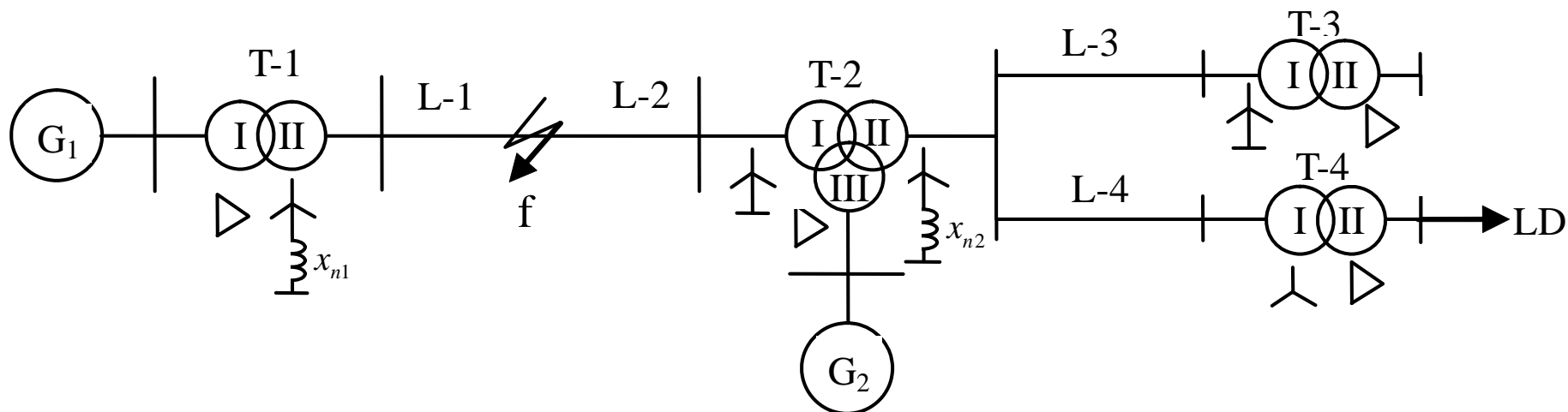
# 7-7 电力系统各序网络的制定

## 算例—负序网络



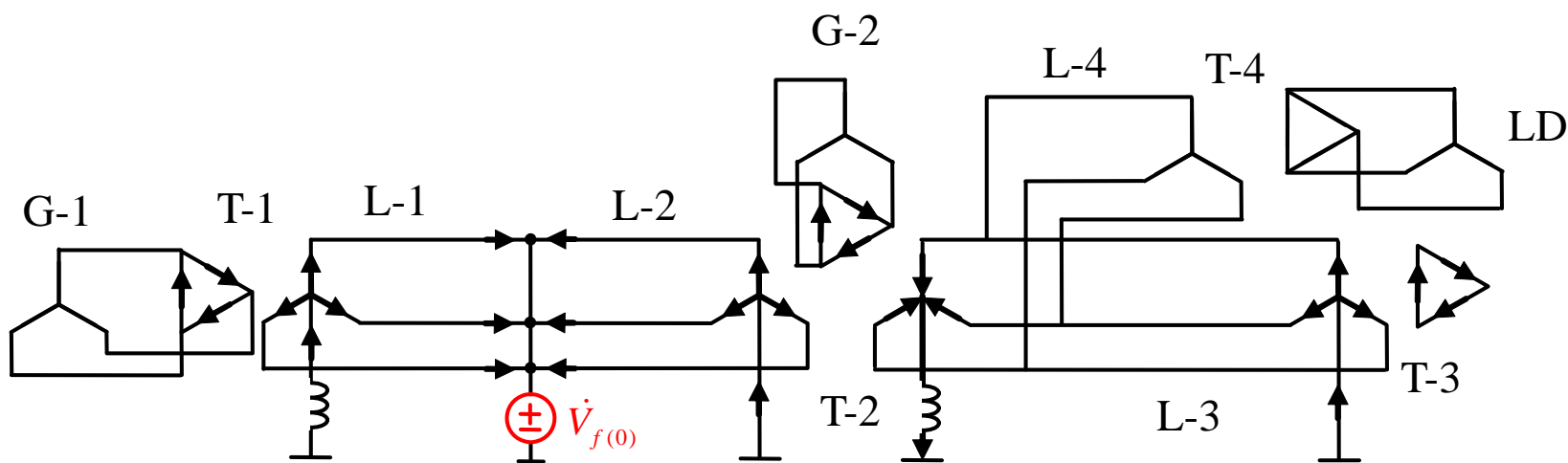
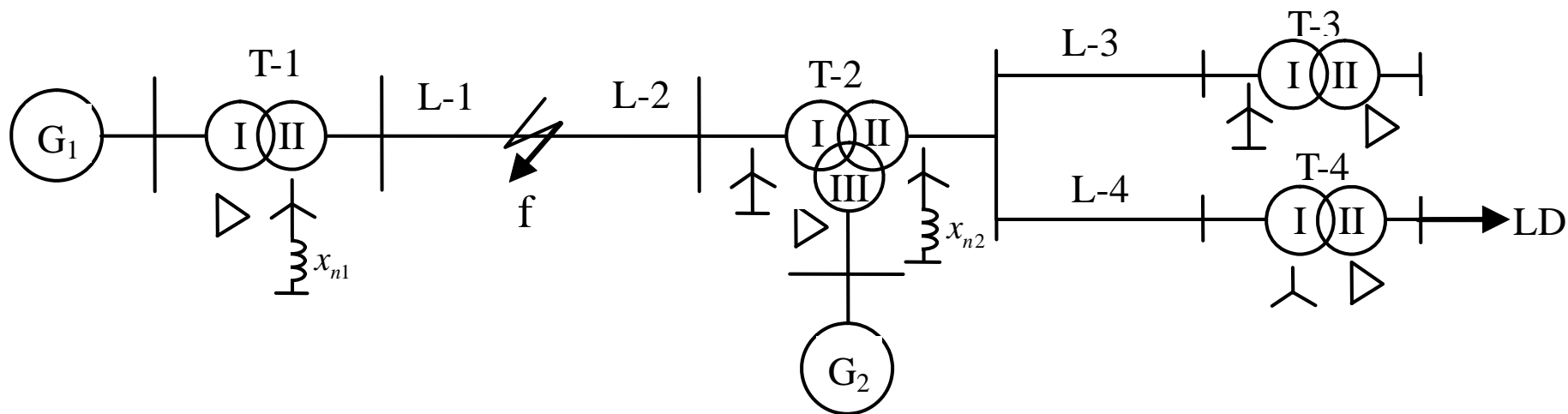
# 7-7 电力系统各序网络的制定

## 算例—零序网络



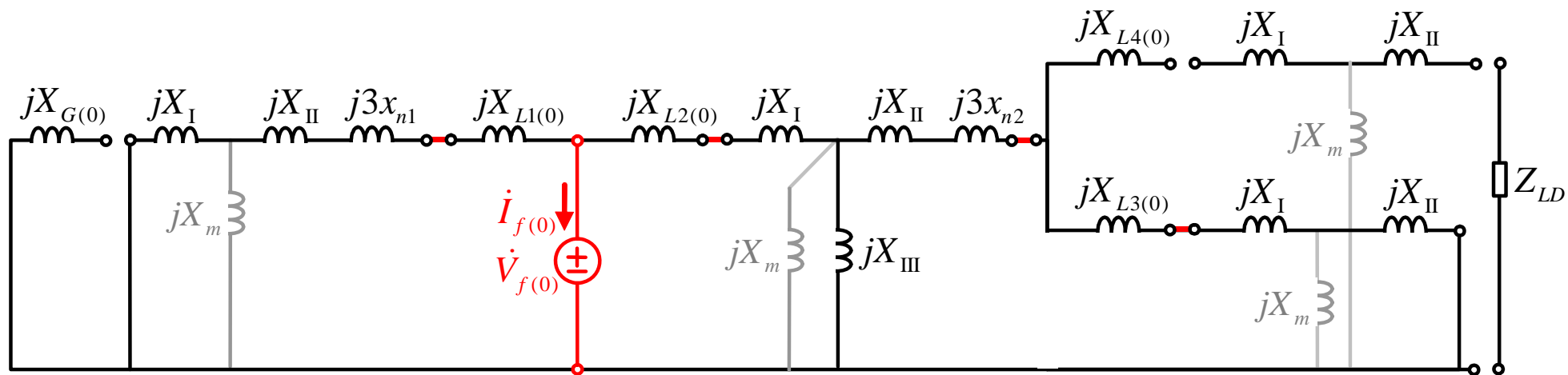
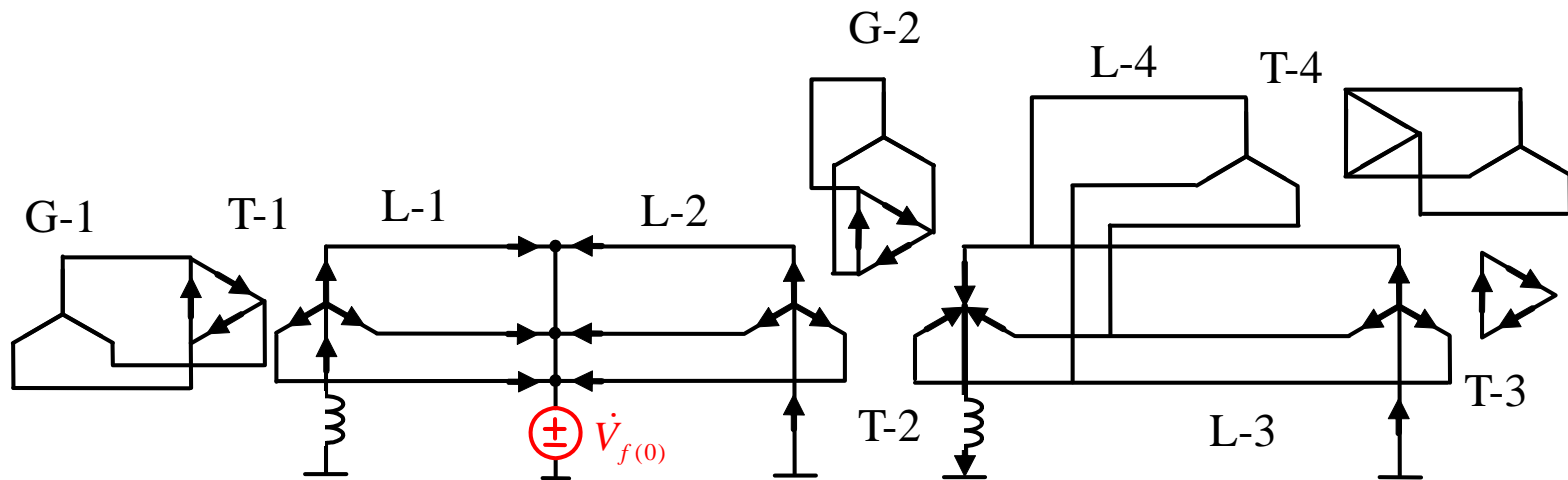
# 7-7 电力系统各序网络的制定

## 算例—零序网络



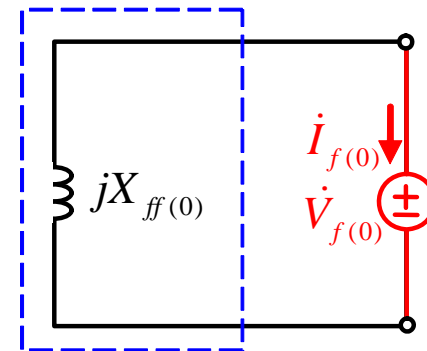
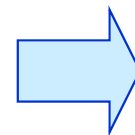
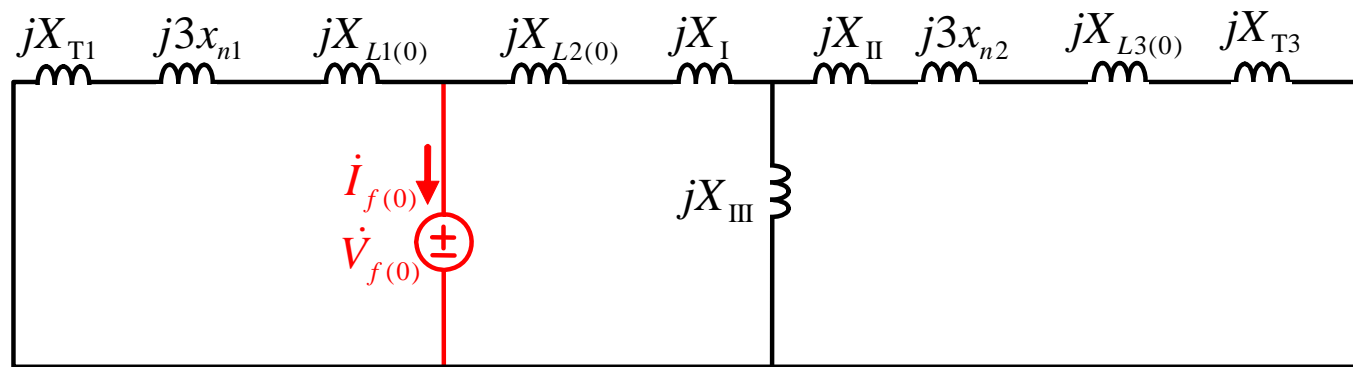
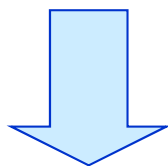
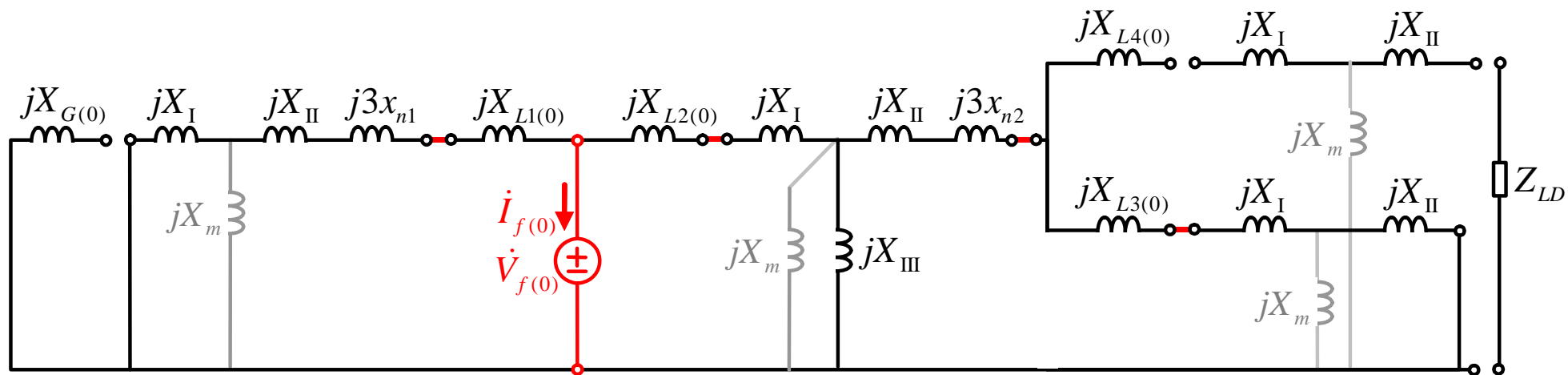
# 7-7 电力系统各序网络的制定

## 算例——零序网络



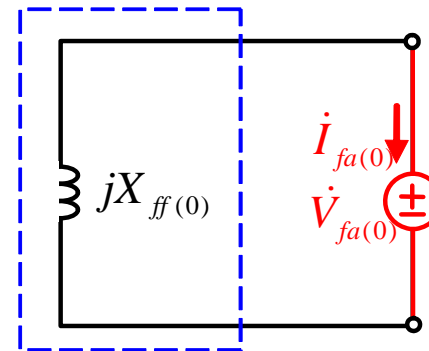
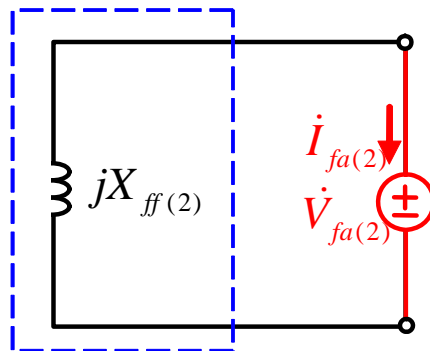
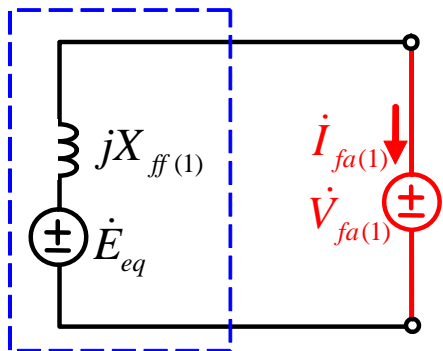
# 7-7 电力系统各序网络的制定

## 算例——零序网络



# 7-7 电力系统各序网络的制定

## 序网方程



$$\dot{V}_{fa(1)} = \dot{E}_{eq} - Z_{ff(1)} \dot{I}_{fa(1)}$$

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

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



# 华中科技大学

Huazhong University of  
Science and Technology

## 本章小结

- ❖ 对称分量法分析不对称故障的原理和方法；
- ❖ 变压器的零序等值电路和参数；
- ❖ 输电线路零序等值电路及参数；
- ❖ 制定序网的原则和方法；



**Do you think so?**

**临阵磨枪，  
不快也光！**

**Ex 7-3, 7-5, 7-7**

**End of Chapter 7**