Fault ⇒
- 1 line to ground
- 2 lins to grand
- 1 line to 1 line
- 3 lines together

open
- 1 conductor open
- 2 conductor open

---

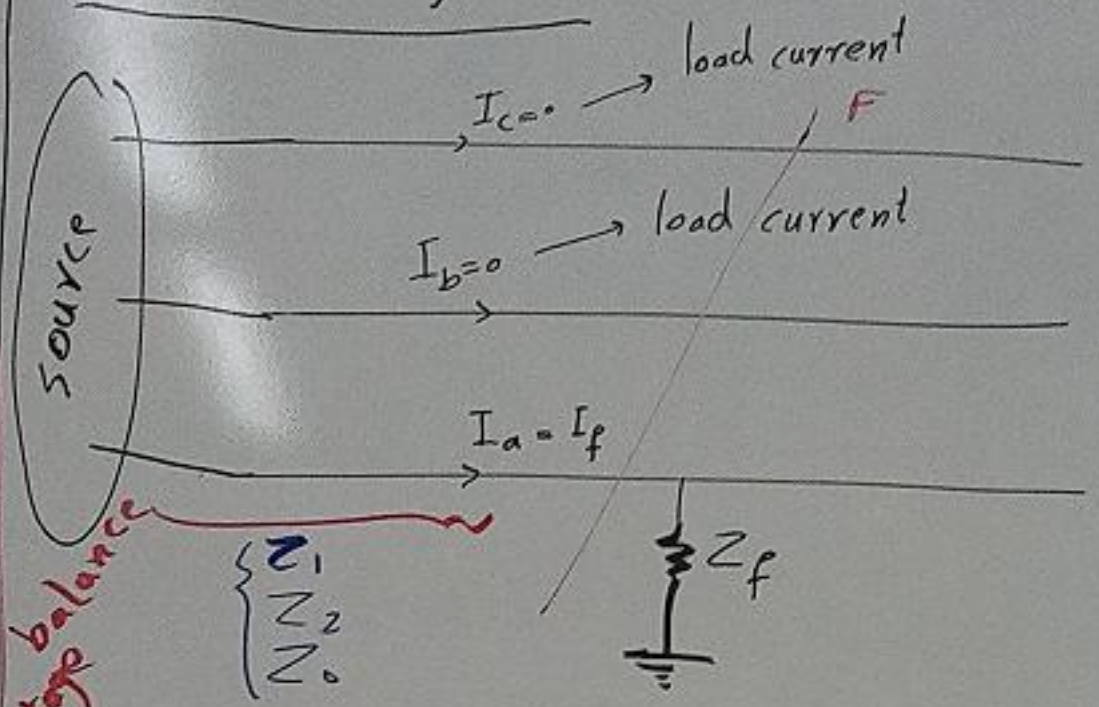
load current << fault current ⟹

omit load current

V_{source} ← no change

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \begin{bmatrix} 1 & 1 & 1 \\ 1 & a^2 & a \\ 1 & a & a^2 \end{bmatrix} \begin{bmatrix} V_0 \\ V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} V_0+V_1+V_2 \\ - - - \\ - - - \end{bmatrix}$$

1 line to ground



F: { V_a, V_b, V_c unbalance

faulted phase ≡ a

$$V_a = Z_f I_a$$

$$\begin{bmatrix} I_0 \\ I_1 \\ I_2 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \begin{bmatrix} I_a \\ 0 \\ 0 \end{bmatrix} = \frac{1}{3} \begin{bmatrix} I_a \\ I_a \\ I_a \end{bmatrix}$$

$$I_0 = I_1 = I_2 = \frac{1}{3} I_a$$

$$V_a = V_0 + V_1 + V_2$$

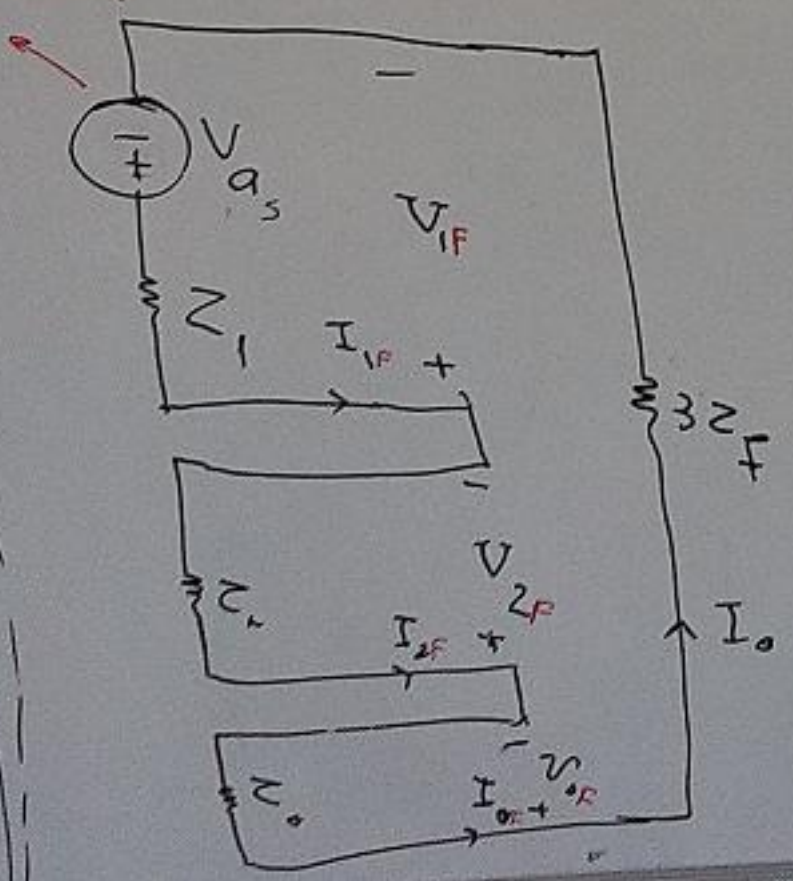
$$V_0 + V_1 + V_2 = 3 Z_f I_f$$

$\Rightarrow$

$$I_0 = I_1 = I_2$$

$$V_a = V_0 + V_1 + V_2$$

balance



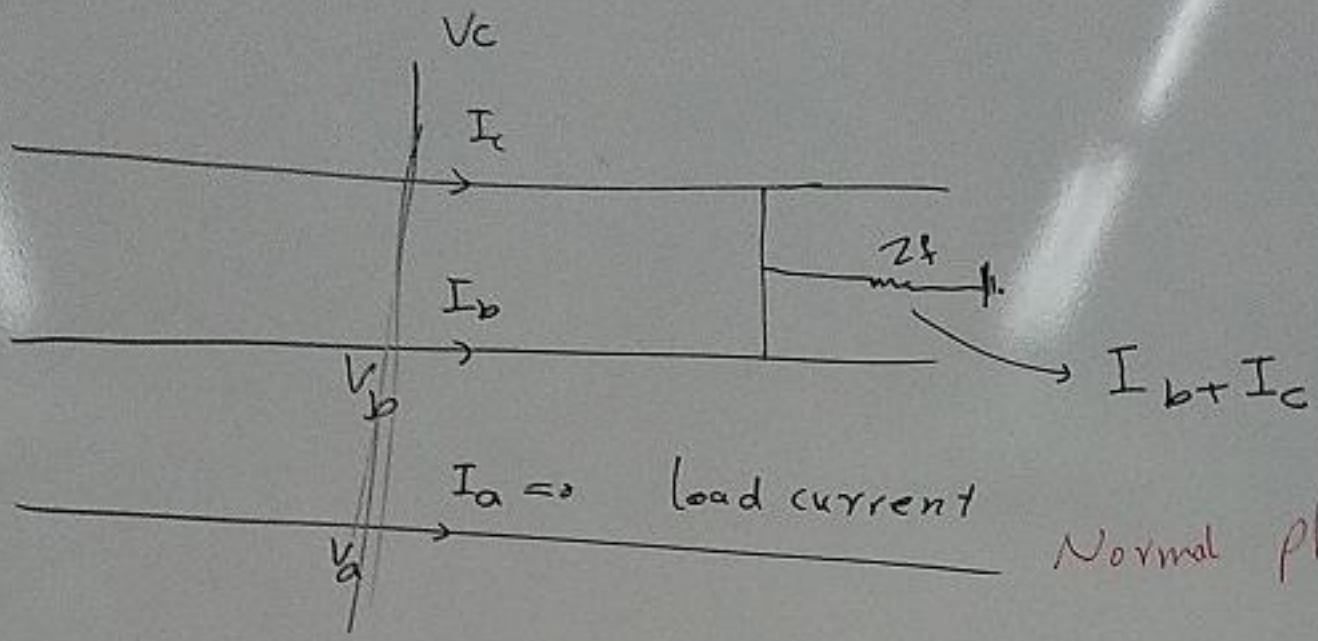
$$I_0 = I_1 = I_2 = \frac{V_a}{Z_1 + Z_2 + Z_0 + 3Z_f}$$

$$I_a = \frac{3V_a}{Z_1 + Z_2 + Z_0 + 3Z_f}$$

$$\begin{cases} V_1 = V_a - Z_1 I_1 \\ V_2 = -Z_2 I_2 \\ V_0 = -Z_0 I_0 \end{cases} \Rightarrow \begin{cases} V_a \\ V_b \\ V_c \end{cases}$$

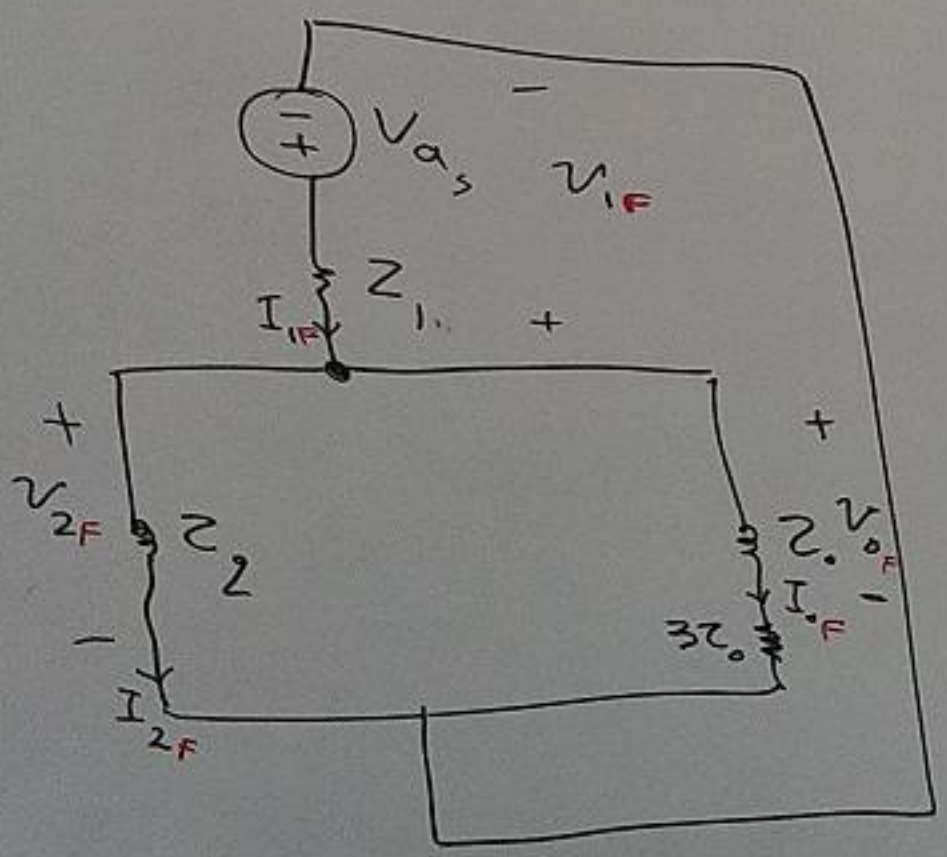
2 lines to ground

1.1



$$V_c = V_b = Z_f (I_b + I_c)$$

$$\begin{cases} I_1 + I_2 + I_0 = 0 \\ V_1 = V_F, \quad V_0 = V_1 + 3Z_0 I_0 \end{cases}$$

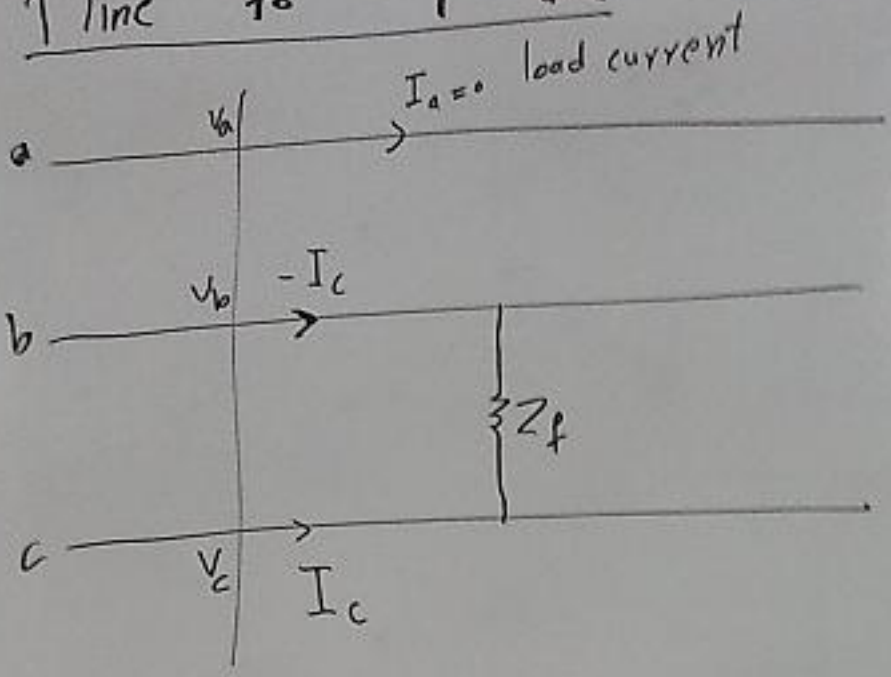


I_0 . −

I_1 −

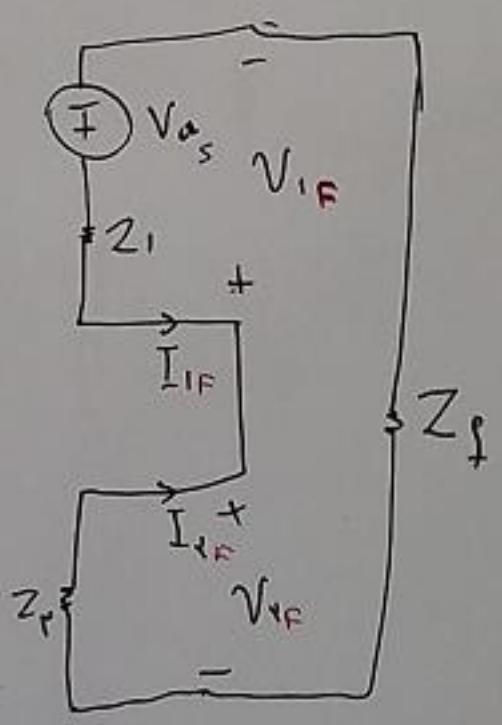
V_1 . − . −

1 line to 1 line



$$V_c - V_b = Z_f I_c \quad , I_b = -I_c$$

$$\begin{cases} I_0 = 0 \ , \ I_2 = -I_1 \\ V_1 - V_2 = Z_f I_1 \ , \ V_1 = V_2 \end{cases}$$



I_0
I_1
V_1
V_2
V_a
V_b