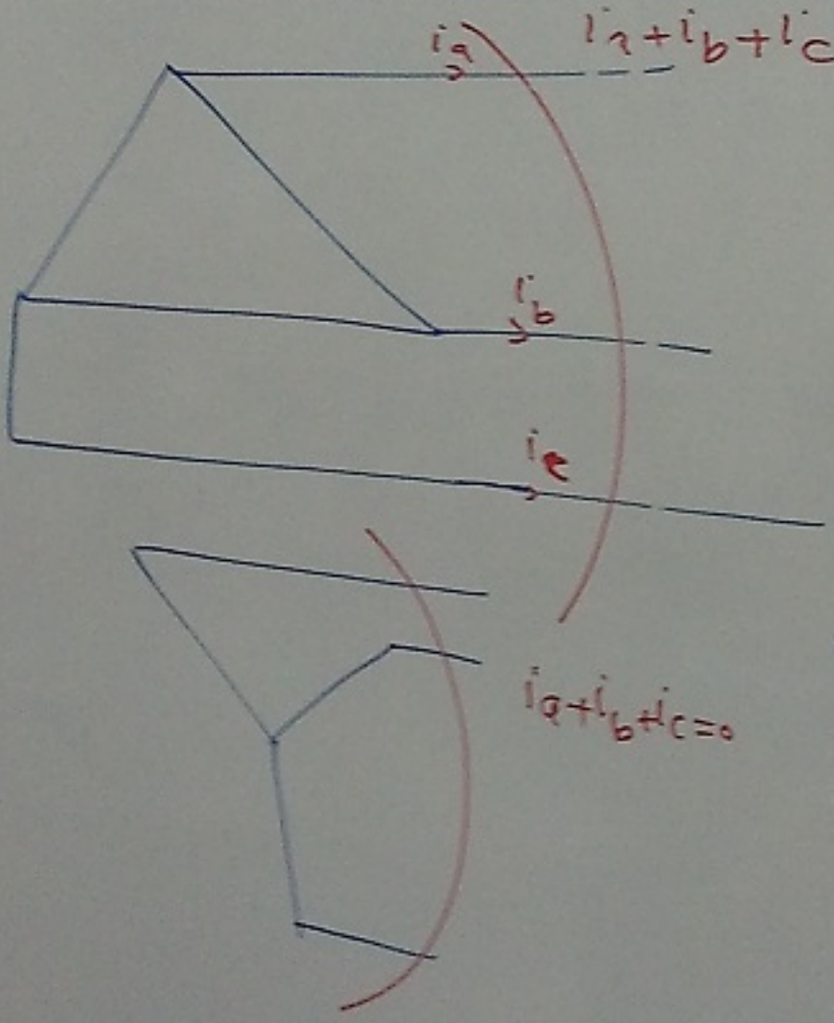
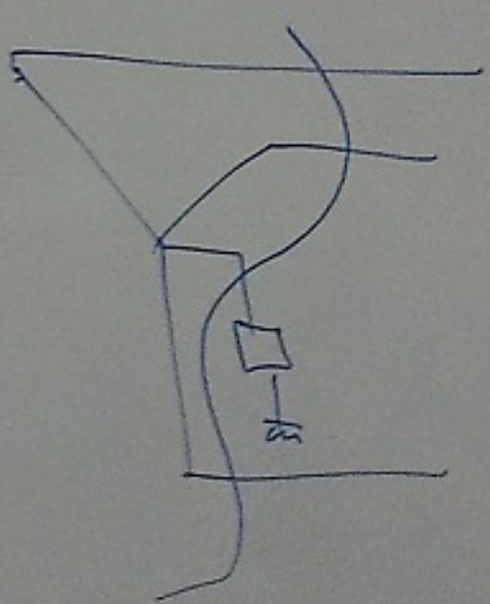
R	a	c	c
S	b	a	b
T	c	b	a

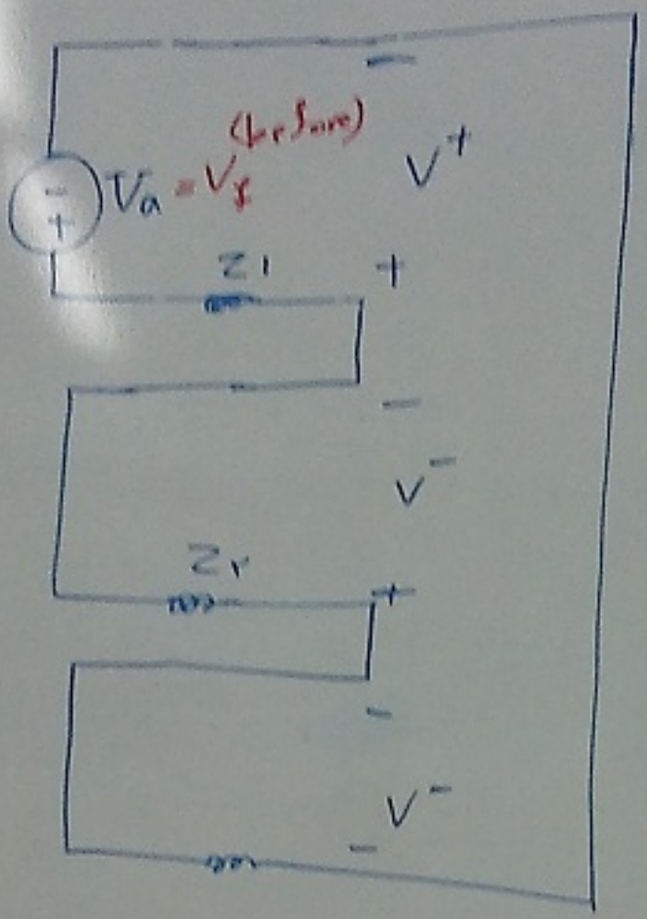
$$\begin{bmatrix} I_a^0 \\ I_a^+ \\ I_a^- \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$



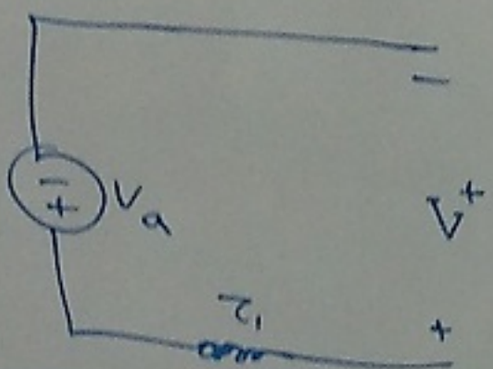
$i_a+i_b+i_c+i_N=0$

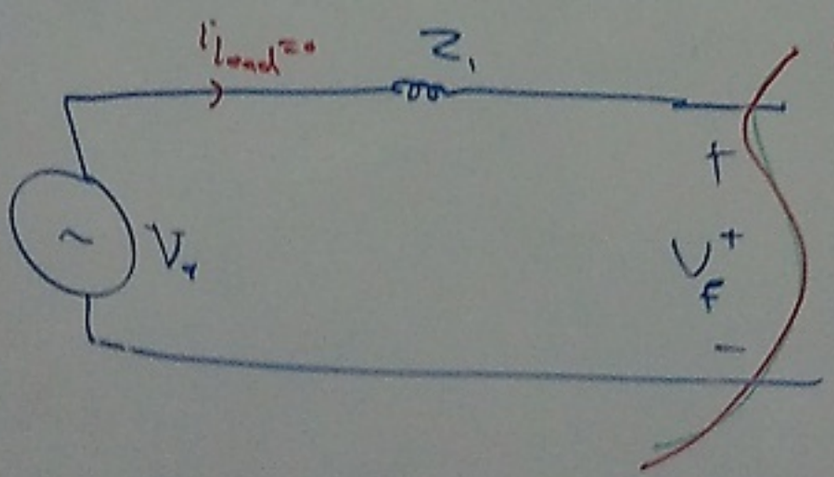


during fault

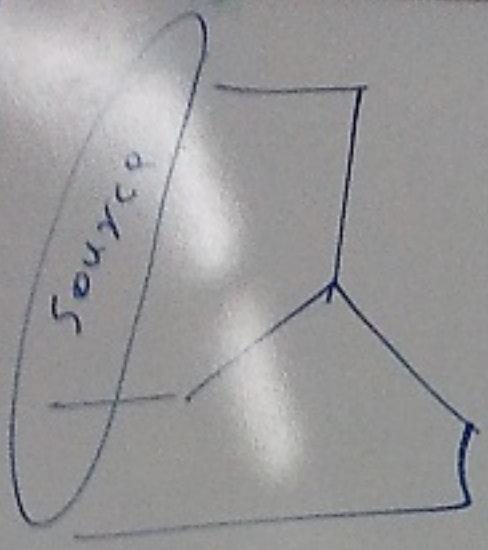


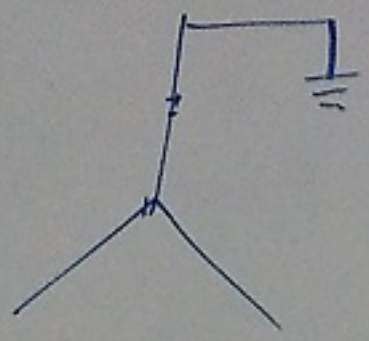
before fault

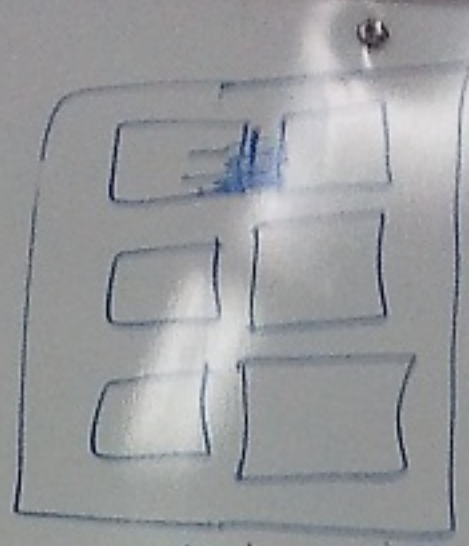




{ before fault
$V_a = V_f^+$

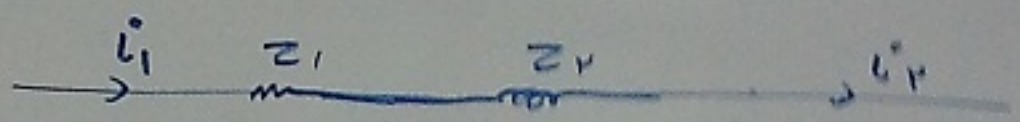






$N_1 i_1 - N_2 i_2 = R\phi$

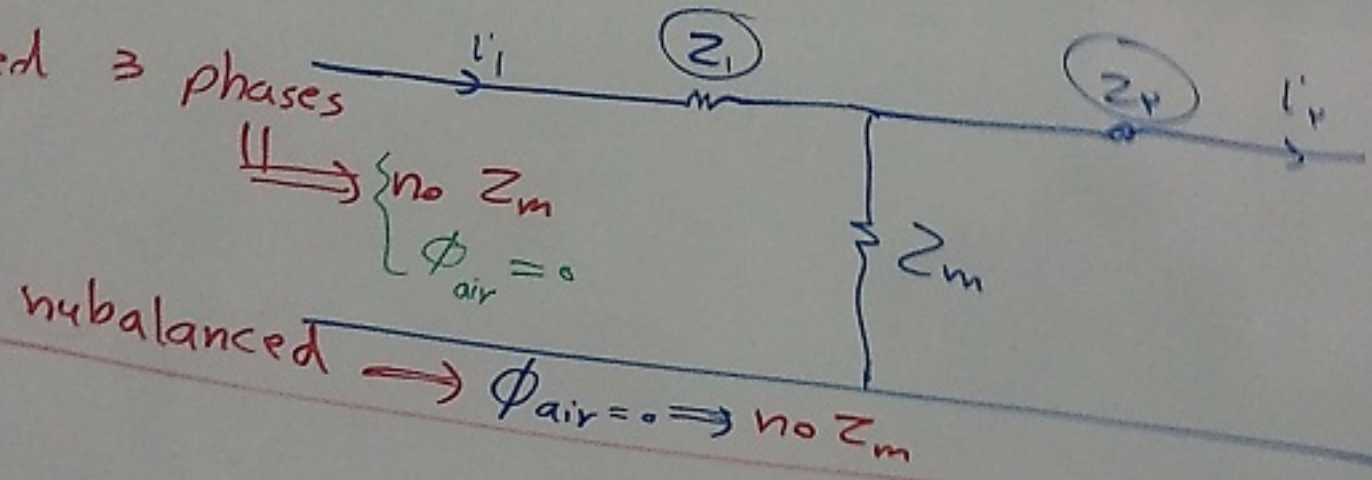
shell



main model

balanced 3 phases ⟹ no z_m, $\phi_{air} = 0$

shell & unbalanced ⟹ $\phi_{air} = 0$ ⟹ no z_m

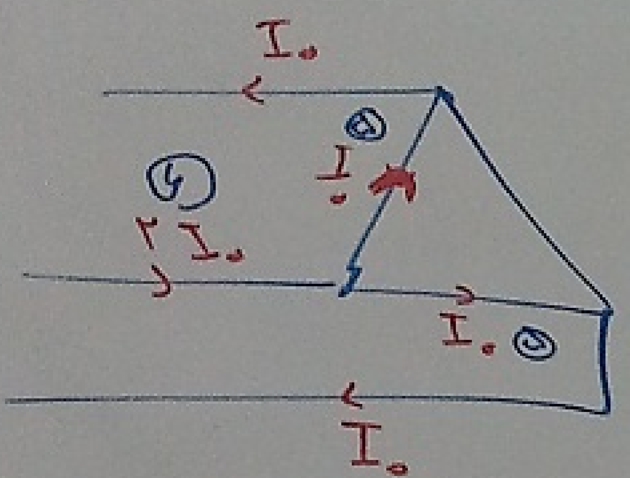


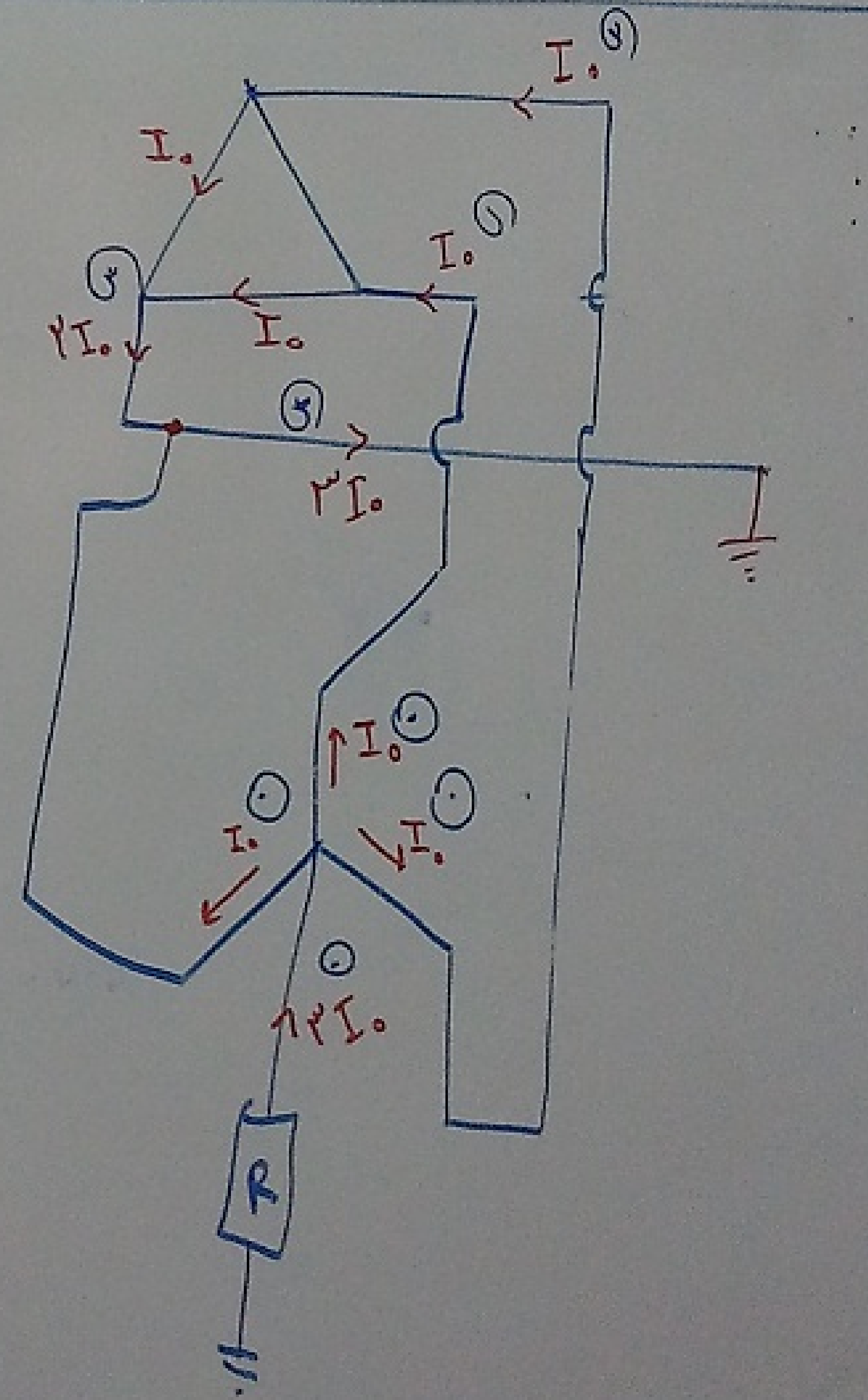
$N_1 i_1 - N_1 i_1 = R\phi$

$i_1 - i_1 = R\phi$

goal { in zero sequence
transformer impedance { to be or not to be

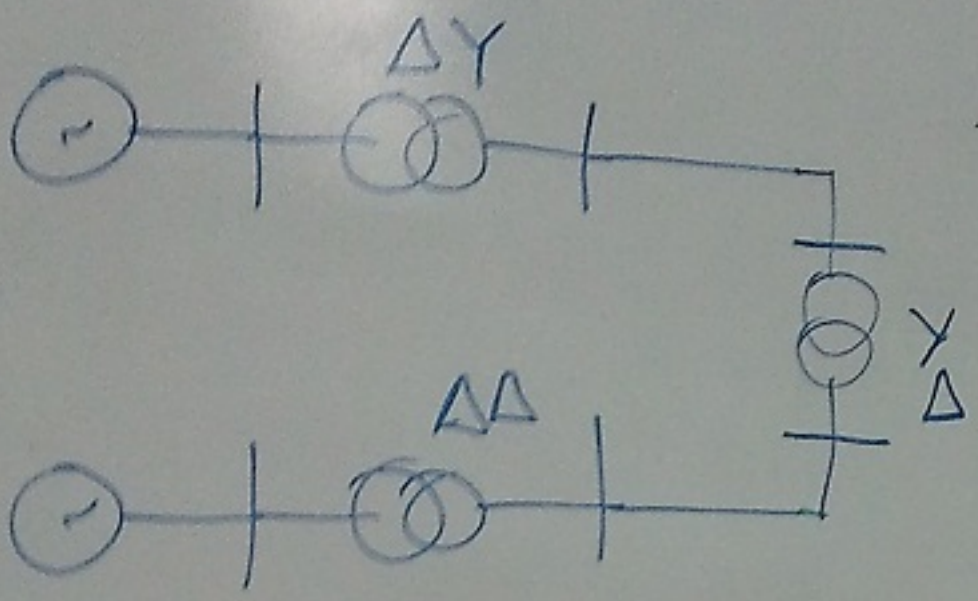
{ 1) { 3 currents homophase ⟹
or
2) single line fault



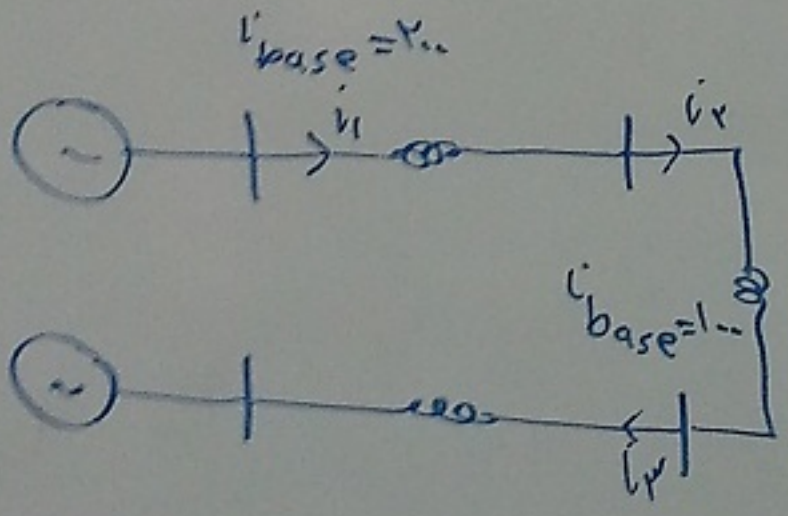


phase shift :

example 1: network connection : respect to phase shift



example: change network to perunit:



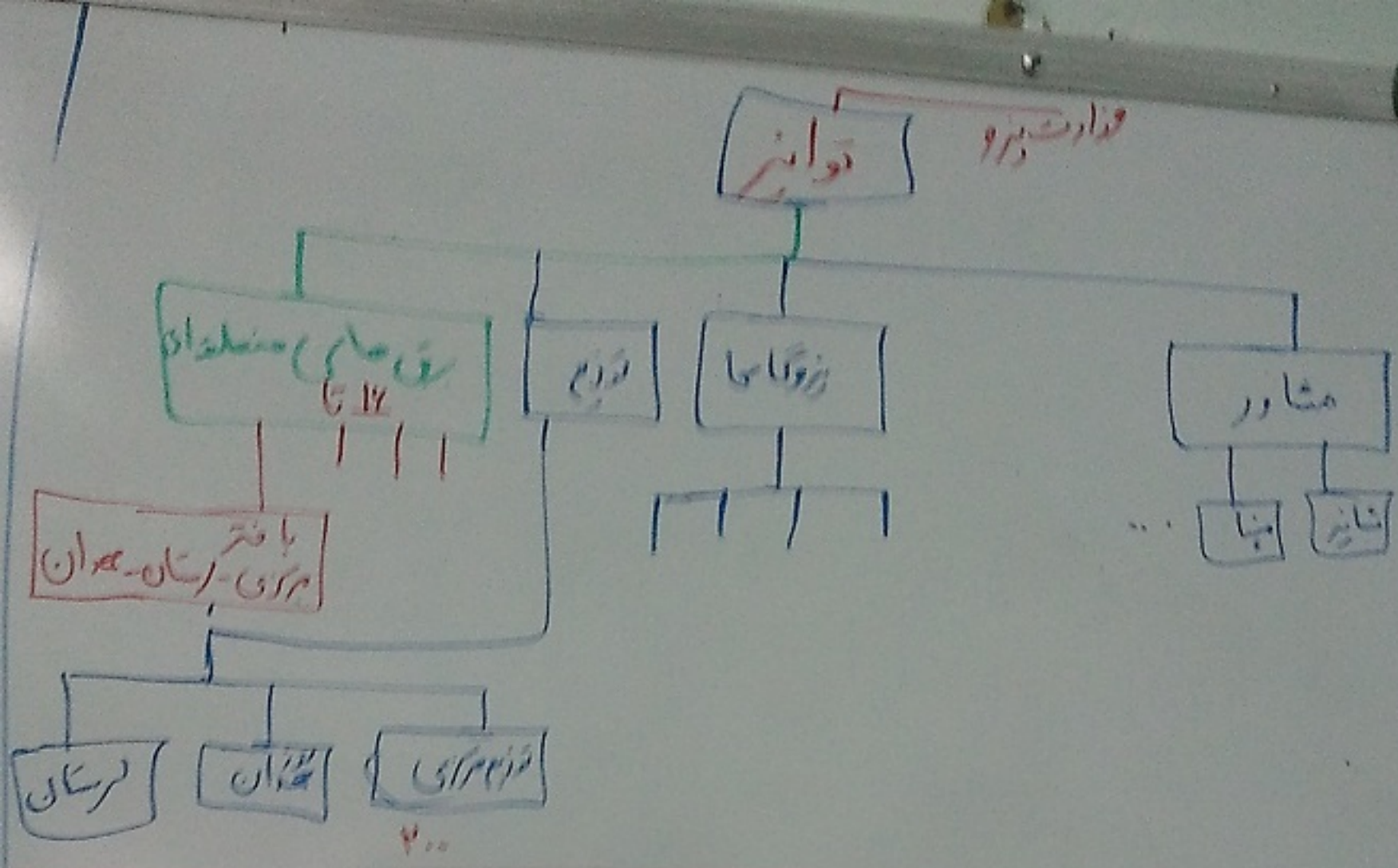
$i_1^{pu} = i_۲ = i_۳ = 1\angle ۲۰^\circ \Rightarrow$

$i_{actual} = i^{pu} \times i_{base}$

$\begin{cases} i_{۱\,actual} = ۲۰۰\angle ۲۰ \\ i_{۲\,actual} = ۱۰۰\angle ۲۰ \end{cases}$

$i_{۲\,actual} = ۱۰۰\angle ۵۰$

(because of phase shift)



phase shift for sequence

$\begin{cases} I^{+} \Longrightarrow \text{according to vector group} \\ I^{-} \Longrightarrow \text{opposite to vector group} \\ I^{\circ} \Longrightarrow \text{no phase shift} \end{cases}$

for each segment