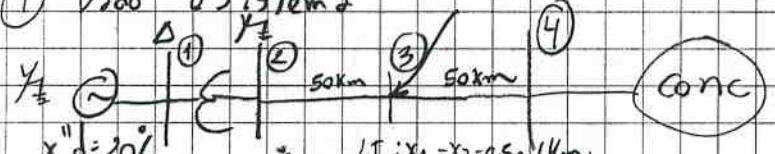
Data: 09 11 07

Raphael Terra - P1 - ASP

Z usada 4 casas decimais // * 10,0

① Dado o sistema



$x''_d = 20\%$ $x_0 = 12\%$ 200 MVA

$x_1 = 10\%$ 200 MVA 13,8/230 kV

LT: $x_1 = x_2 = 0,5\Omega/1Km$ $x_0 = 3x_1$

$N_{cc}^{3\phi} = 2000$ MVA

$N_{cc}^{1\phi} = 1600$ MVA

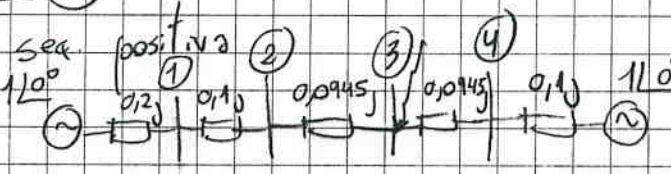
$N_b = 200$ MVA

① Det I_{cc} 3ϕ em ampéres

b) Det I_A, I_B e I_C em amperes no gerador durante cc 3ϕ

Solução ①

a)



Gerador → $x_1 = 0,2 \cdot \frac{200}{200} = 0,2$ p.u

Trafo → $x_1 = 0,1$ p.u

LT → $x = \frac{0,5 \cdot 50}{\left(\frac{230kl^2}{200M}\right)} = 0,0945$ p.u

sistema

$x_1 = x_2 = \frac{200}{2000} = 0,1$ p.u

$Z_{eq_{cc}} = (0,3945j \,//\, 0,1945j) = 0,1303j$

$i_{cc}^{3\phi} = \frac{1}{0,1303j} = 7,6762 \angle -90°$ p.u

$I_b = \frac{200M}{\sqrt{3} \cdot 230 \times 10^3} = 502,0437$ A //

$I_{cc}^{3\phi} = 3853,7879 \angle -90°$ A // (2,0)

b) LADO esquerdo do curto (onde está o gerador):

$I_E = \frac{7,6762 \angle -90° \cdot (0,1945j)}{(0,1945j + 0,3945j)} = 2,5348 \angle -90°$ p.u

↑ contribuição do LE.

Devido termos um Trafo Δ/Y_2 :.

$i_{G1} = i_A = 2,5348 \angle -90° \cdot 1 \angle -30° = 2,5348 \angle -120°$ p.u // (1,0)

$I_{base} = \frac{200M}{\sqrt{3} \cdot 13,8k} = 8361,3952$ A ⇒ $I_A = 21.209,6734 \angle -120°$ A //

$I_B = 21209,6734\, a^2 = 21209,6734 \angle 120°$ A //

$I_C = 21209,6734\, a = 21.209,6734 \angle 0°$ A //

② Det I_{cc} 3ϕ através de Zbus

$$y_{11} = \frac{1}{0,2j} + \frac{1}{0,1j}$$

$$y_{22} = \frac{1}{0,1j} + \frac{1}{0,0945j}$$

$$y_{33} = \frac{1}{0,0945j} + \frac{1}{0,0945j} =$$

$$y_{44} = \frac{1}{0,0945j} + \frac{1}{0,1j}$$

$$y_{12} = y_{21} = \frac{-1}{0,1j}$$

$$y_{23} = y_{32} = \frac{-1}{0,0945j}$$

$$y_{34} = y_{43} = \frac{-1}{0,0945j}$$

$$Y_{Bus} = j\begin{bmatrix} -15 & 10 & 0 & 0 \\ 10 & -20,5820 & 10,582 & 0 \\ 0 & 10,582 & -21,1640 & 10,582 \\ 0 & 0 & 10,582 & -20,5820 \end{bmatrix}$$

$$[Y_{Bus}]^{(-1)} = [Z_{bus}]$$

$$Z_{bus} = j\begin{bmatrix} 0,1321 & 0,0981 & 0,0660 & 0,0340 \\ 0,0981 & 0,1472 & 0,0991 & 0,0509 \\ 0,0660 & 0,0991 & 0,1303 & 0,0670 \\ 0,0340 & 0,0509 & 0,0670 & 0,0830 \end{bmatrix}$$

O curto-circuito ocorre na barra 3 :.

$$i_{cc}^{3\phi} = \frac{1}{0,1303j} = 7,6762 \angle -90° \text{ pu}$$

(21°)

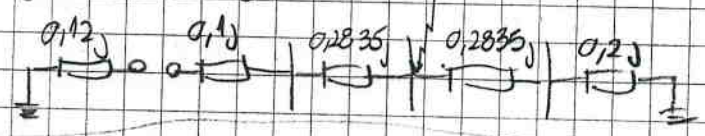
$$I_{cc}^{3\phi} = i_{cc}^{3\phi} \cdot 502,0437 = 3853,7879 \angle -90° \text{ A}$$

Raphael Terra - Continuação P1 - ASP

Data: 09/11/07

(3) a) Det Icc 1φ

• Seq. zero



sistema.

LT:

$x_1 = x_2 = 0,1$ pu $\times 0,4$

$x_0 = 3x_1 = 0,2835_{pu}$

$x_1 + x_2 + x_0 = \frac{3.200}{1500}$

$x_0 = 0,4 - 0,2$

$x_0 = 0,2$ p.u

$Z_{eq_{1cc_0}} = (0,3835j \,//\, 0,4835j)$

$Z_{eq_{1cc_0}} = 0,2139j$ p.u

• Já foi calculado a impedância de seq. positiva no 1 a), que é a mesma, neste problema, da seq. negativa. Então:

$$\dot{I}_{cc}^{1\phi} = \frac{3}{0,1303j \times 2 + 0,2139j}$$

$x_1 = x_2$; x_0

$$\dot{I}_{cc}^{1\phi} = \frac{3}{0,4745j} = 6,3229\angle -90^\circ \text{ p.u}$$

$I_{cc}^{1\phi} = 6,3229\angle -90^\circ \cdot I_b$, sendo $I_b = 502,0437$ A (já calculado)

$I_{cc}^{1\phi} = 3174,3677\angle -90^\circ$ A //

b) I_A, I_B e I_C (no gerador) durante cc 1φ:

$I_{a1} = I_{a2} = I_{a0} = \frac{6,3229\angle -90^\circ}{3} = 2,1076\angle -90^\circ$ p.u //

* Lado esquerdo:

seq. positiva e negativa:

$I_{\pm} = 2,1076\angle -90^\circ \cdot \frac{0,1945j}{(0,1945j + 0,3945j)} = 0,6960\angle -90^\circ$ pu

seq. zero:

não há seq. zero no G1 devido ao trafo Δ Y :.

No gerador:

$I_{G_1} = 0,6960\angle -120^\circ$ pu e $I_{G_2} = 0,6960\angle -60$ p.u

(2) defasagem +30° e -30° (1)

continua verso //

b) $\bar{i}_A = \phi + 0{,}6960\angle -120° + 0{,}6960\angle -60° = 1{,}2055\angle -90°$ p.u

$i_B = \phi + 0{,}6960\angle -120 \cdot a^2 + 0{,}6960\angle -60° \, a = 1{,}2055\angle 90°$ p.u

$i_C = \phi + 0{,}6960\angle -120 \cdot a + 0{,}6960\angle -60° \, a^2 = 0$ pu

$I_A = 1{,}2055\angle -90° \cdot I_B$ → onde $I_B = 8367{,}3952$ A → já calculado no 1

$I_A = 10086{,}8949\angle -90°$ A //

$I_B = 10086{,}8949\angle 90°$ A //

$I_C = 0$ //

1,5

c) Det V_A, V_B e V_C no ger. durante o c-t

$v_{a1} = 1\angle 0° - (0{,}6960\angle -120° \times 0{,}2\angle 90°)$

$v_{a1} = 0{,}8822\angle 4{,}5250°$ p.u //

$v_{a2} = -(0{,}6960\angle -60°) \times (0{,}2\angle 90°)$

$v_{a2} = 0{,}1392\angle -150°$ p.u //

$v_{a0} = \phi$ //

1,5

$v_A = v_{a1} + v_{a2} + \cancel{v_{a0}}^{\phi} = 0{,}7589\angle 0°$ p.u

$v_B = \cancel{v_{a0}}^{\phi} + a^2 v_{a1} + a v_{a2} = 0{,}8822\angle 244{,}5250° + 0{,}1392\angle -30° = 0{,}9039\angle -106{,}644°$ pu

$v_C = \cancel{v_{a0}}^{\phi} + a v_{a1} + a^2 v_{a2} = 0{,}8822\angle 124{,}5250° + 0{,}1392\angle 90° = 0{,}9931\angle 120{,}2308°$ p.u

$V_A = v_a \cdot V_{base}$ → $V_{base} = 13{,}8$ kV //

$V_A = 10{,}4728\angle 0°$ kV //

$V_B = 12{,}4738\angle -106{,}644°$ kV //

$V_C = 13{,}7045\angle 120{,}2308°$ kV //

P1 - 2004/2

Data: 08 / 11 / 2007

1) Passe o sistema P.U, montando a sequência zero do problema (letra a)

$N_{cc}^{1\phi}{}_{sist} = 600\ MVA$; $X_0^{LT} = 3X_1$; $X_0^{trafo} = X_1$

$N_b = 100\ MVA$

(1)

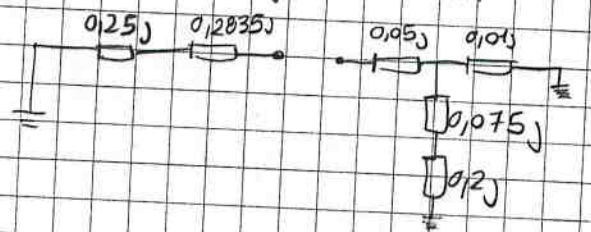
Solução

sistema:

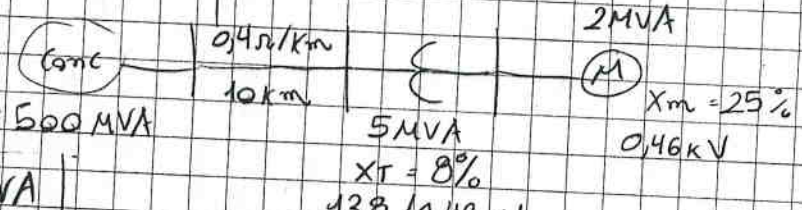
$X_1 = X_2 = \frac{100}{800} = 0{,}125_j\ pu$

$X_1 + X_2 + X_0 = \frac{3.100}{600} \Rightarrow 0{,}25 + X_0 = 0{,}5 \Rightarrow X_0 = 0{,}25_j\ p.u$

$X_0^{LT} = 3X_1 = 0{,}2835_j$; $X_{0_1} = X_{1_T}$



1) Passe o sistema para P.U:



$N_{cc}^{3\phi} = 500\ MVA$

$N_b = 5\ MVA$

sistema:

$X_{conc} = \frac{5}{500} = 0{,}01_j\ p.u$

Transf:

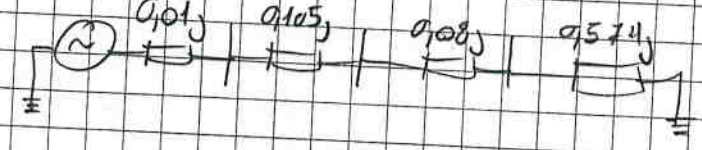
$X = 0{,}08_j\ pu$

LT:

$X = \frac{0{,}4 . 10}{(13{,}8k^2/5M)} = 0{,}105_j\ p.u$

carga:

$X = 0{,}25 . \frac{5M}{2M} \frac{(0{,}46 \times 10^3)^2}{(0{,}48 \times 10^3)^2} = 0{,}574_j\ p.u$



Prova - P1 2004/2 - ASP 1

2) Determine $I_{cc}^{3\phi}$

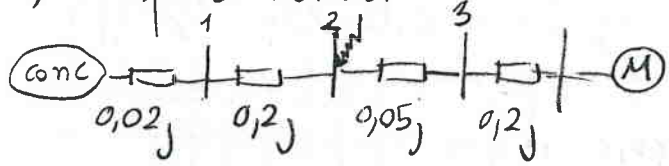
a) de forma analítica

b) de forma matricial

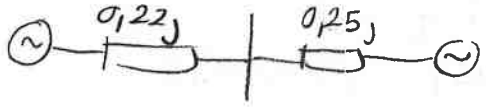
c) Determine as contribuições da concessionário e do motor de forma analítica

d) Determine a tensão na concessionária de forma analítica

e) Idem d) de forma matricial



Solução

a) 

$\Rightarrow Z_{eq} = 0{,}25 // 0{,}22$

$Z_{eq} = 0{,}117j$

$$I_{cc}^{1\phi} = \frac{1}{0{,}117j} = 8{,}54\angle -90^\circ \text{ p.u} \quad //$$

b) $Y_{BUS} = \begin{bmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{32} & Y_{33} \end{bmatrix}$

$$Y_{11} = \frac{1}{0{,}02j} + \frac{1}{0{,}2j} = -55j \; // \quad Y_{33} = \frac{1}{0{,}05j} + \frac{1}{0{,}2j} = -25j \; //$$

$$Y_{22} = \frac{1}{0{,}2j} + \frac{1}{0{,}05j} = -25j \; // \quad Y_{21} = Y_{12} = -\frac{1}{0{,}2j} = 5j \; //$$

$Y_{13} = Y_{31} = 0$ //

$$Y_{23} = Y_{32} = \frac{-1}{0{,}05j} = 20j \; // \quad Y_{BUS}^{-1} = Z_{bus} = \begin{bmatrix} 1{,}914\times10^{-2}j & 1{,}063\times10^{-2}j & 8{,}51\times10^{-3}j \\ 1{,}063\times10^{-2}j & 0{,}117j & 9{,}361\times10^{-2} \\ 8{,}510\times10^{-3}j & 9{,}36\times10^{-2}j & 0{,}114\times10^{-2}j \end{bmatrix}$$

$$I_{cc}^{1\phi} = \frac{1}{0{,}117j} = 8{,}54\angle -90^\circ$$

c) $$I_{conc} = \frac{8{,}54\angle -90^\circ \cdot 0{,}25j}{0{,}47j} = 4{,}54\angle -90^\circ \text{ p.u} \quad // \qquad I_{motor} = (8{,}54 - 4{,}54)\angle -90^\circ = 4{,}00\angle -90^\circ \text{ p.u} \quad //$$

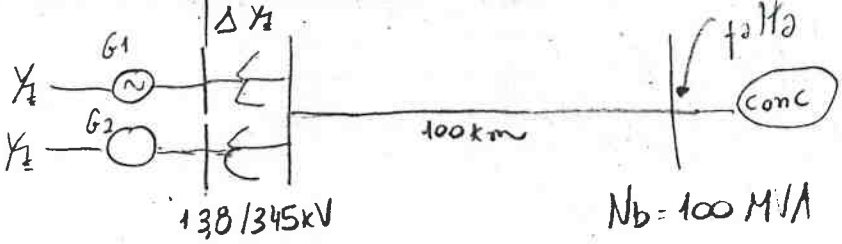
d) $V_{conc} = 1 - (4{,}54\angle -90^\circ \cdot 0{,}02\angle 90^\circ) \Rightarrow V_{conc} = 0{,}9092\angle 0^\circ$ p.u

e) $$V_a^F = V_a^\circ - \frac{Z_{ai}}{Z_{ii}} \cdot V_i^\circ \Rightarrow V_a^F = 1 - \frac{1{,}063\times10^{-2}j}{0{,}117j} \cdot 1$$

$V_a^F = 0{,}909\angle 0^\circ$ p.u //

Prova - P1 - 2006/2

1- Determine para o sistema de transmissão:



$N_{cc}\ 3\phi = 2000\ MVA$

$N_{cc}\ 1\phi = 1500\ MVA$

$N_b = 100\ MVA$

G: $x1 = x2 = 16\%$ $\quad x0 = 10\% \rightarrow 150\ MVA$ cada

Trafos: $x1 = x2 = x0 = 8\% \rightarrow 150\ MVA$ cada

LT: $x1 = x2 = 0,3\ \Omega/Km$ (cond. geminados) ; $x0 = 2,5 x1$

Determine:

a) $I_{cc}\ 3\phi$ no pto indicado

b) V_A, V_B, V_C no G1 durante cc 3ϕ

c) $I_{cc}\ 1\phi$ no ponto indicado

d) V_A, V_B, V_C no G1 durante cc 1ϕ

Solução LTs: $x1 = \dfrac{0,3 \cdot 100}{\frac{(345k)^2}{100M}} = 2,52 \times 10^{-2}$ p.u // ; $x2 = 2,52 \times 10^{-2}$ p.u // ; $x0 = 6,30 \times 10^{-2}$ p.u //

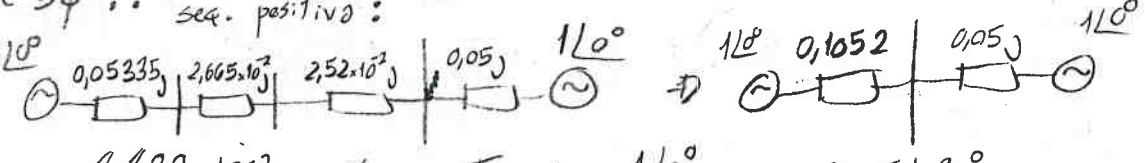
Geradores: $x1 = x2 = \dfrac{0,16 \cdot 100}{150} = 0,1067$ p.u // $\quad x0 = 6,67 \times 10^{-2}$ p.u //

Trafos: $x1 = x2 = x0 = \dfrac{0,08 \cdot 100}{150} = 5,33 \times 10^{-2}$ p.u //

sistema: $x1 = x2 = \dfrac{100}{2000} = 0,05$ p.u //

$x1 + x2 + x0 = \dfrac{3 \cdot 100}{1500} \Rightarrow 0,05 + 0,05 + x0 = 0,2 \Rightarrow x0 = 0,1$ p.u //

a) cc 3ϕ: seq. positiva:



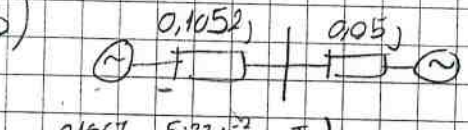
$Z_{eq} = 3,389 \times 10^{-2}$ p.u // $\quad I_{cc\ 3\phi} = \dfrac{1\angle 0°}{3,389 \times 10^{-2}\ j} = 29,5\angle -90°$ p.u

$I_B = \dfrac{100M}{\sqrt{3} \cdot 345 \cdot 10^3} = 167,35A$ // $\quad I_{cc\ 3\phi} = 4936,825\angle -90°$ A //

Continuação P1 2006/2

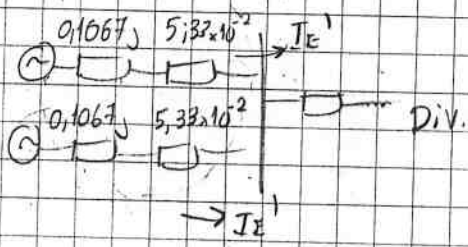
Data: 08/11/2007

b)



$$\dot{I}_E = \frac{-29,5 \cdot 0,95}{(0,05 + 0,1052)\,j} = 9,504 \angle -90^\circ \text{ p.u}$$

(8)



Div. corrente:

$$\dot{I}_E' = \frac{9,504 \angle -90^\circ}{2} = 4,752 \angle -90^\circ \text{ p.u}$$

cada gerador: $\dot{I}_{G_{cada}} = 4,752 \angle -90^\circ \cdot \angle -30^\circ \Rightarrow \dot{I}_{G_{cada}} = 4,752 \angle -120^\circ$ p.u

$$\dot{V}_{AG1} = 1 - (0,107 \angle 90^\circ \times 4,752 \angle -120^\circ)$$

$$\dot{V}_{AG1} = 0,6146 \angle 24,43^\circ \text{ p.u}$$

$$\dot{V}_{AG1} = 8,482 \angle 24,43^\circ \text{ kV} \quad //$$

$$\dot{V}_{BG1} = a^2 \cdot 8,482 \angle 24,43^\circ \text{ kV} \quad //$$

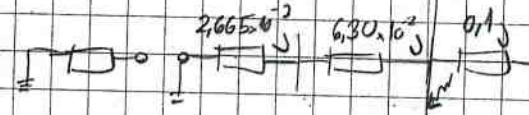
$$\dot{V}_{CG1} = a \cdot 8,482 \angle 24,43^\circ \text{ kV} \quad //$$

e) I_{cc} 1ϕ no ponto indicado

seq. positiva: $Z_{eq_1} = 3,389 \times 10^{-2}$ j

seq. negativa: $Z_{eq_2} = 3,389 \times 10^{-2}$ j

seq. zero:



$$Z_{eq_0} = \frac{0,1 \cdot 0,089}{(0,1 + 0,089)\,j} = 4,70 \times 10^{-2} \text{ j}$$

$$\dot{I}_{cc_{1\phi}} = \frac{3 \cdot 1 \angle 0^\circ}{3Z_f^{\phi} + 3,389 \times 10^{-2} \times 2 + 4,70 \times 10^{-2}}$$

$$\Rightarrow \dot{I}_{cc_{1\phi}} = 26,137 \angle -90^\circ \text{ p.u}$$

$$\dot{I}_{cc_{1\phi}} = 26,137 \angle -90^\circ \cdot 167,35 \Rightarrow \dot{I}_{cc_{1\phi}} = 4374,02 \angle -90^\circ \text{ A} \quad //$$

$\dot{I}_A = 4374,02 \angle -90^\circ$ A ; $\dot{I}_B = 0$ // $\dot{I}_C = 0$ //

Continuação | P1 - 2006/2 |

f) $I_{a0} = I_{a1} = I_{a2} = \frac{I_{cc}}{3} = 8,712 \angle -90°$ p.u

$I_{A_E} = 8,712 \angle -90° \cdot \frac{0,05j}{(0,1052j + 0,05j)} = 2,806 \angle -90° j$

cada gerador:

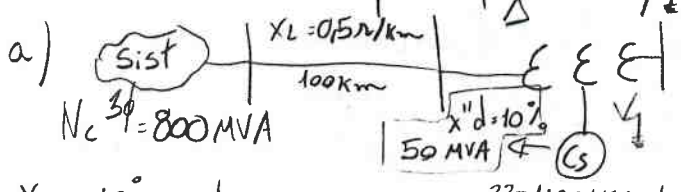
- $I_{A_1}^G = 1,403 \angle -90° \cdot 1 \angle -30° = 1,403 \angle -120°$ p.u //
- $I_{A_2}^G = 1,403 \angle -60°$ p.u //
- $I_{A_0}^G = 0$ //

- $V_{A1} = 1 - (1,403 \angle -120° \cdot 0,1067 \angle +90°) \Rightarrow V_{A1} = 0,87 \angle 4,91°$ p.u
- $V_{A2} = 0 - (1,403 \angle -60° \cdot 0,1067 \angle +90°) \Rightarrow V_{A2} = 0,15 \angle -150°$ p.u

- $V_A = V_{A_0} + V_{A1} + V_{A2} = 0,737 \angle -4,16°$ p.u //
- $V_B = V_{A0} + a^2 \cdot V_{A1} + a V_{A2} = 0,87 \angle 244,91 + 0,15 \angle -30° = 0,895 \angle -105,4°$ p.u
- $V_C = V_{A0} + a V_{A1} + a^2 V_{A2} = 0,87 \angle 124,91 + 0,15 \angle 90° = 0,996 \angle 119,96°$ p.u

P1 - 2004/4

1) Passe o sistema para p.u:

a) 

$X_{PS} = 12\%$ → base 200 MVA — 230/138/13,8 kV (P / S / T)

$X_{PT} = 25\%$ → base 200 MVA — 200 / 200 / 150

$X_{ST} = 17\%$ → base 200 MVA

$N_b = 100$ MVA

Solução

LT: $x_1 = \frac{0,5 \cdot 100}{(230k^2/100M)} = 9,45 \times 10^{-2} j$ p.u //

$X_P = \frac{(0,12 + 0,25 - 0,17)}{2} \cdot \frac{100}{200} = 0,05 j$ pu //

$X_S = 0,01 j$ p.u //; $X_T = 0,075 j$ pu //

Cs: $x''d = 0,10 \cdot \frac{100}{50} = 0,2 j$ p.u //

$n_{cc} = \frac{N_{cc}}{N_b} = \frac{800}{100} = 8$ pu $z_{cc} = \frac{1}{8} \Rightarrow z_{cc} = 0,12$