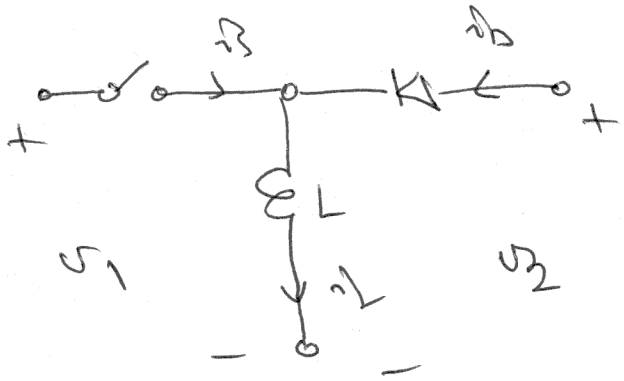
09 MAY 2016

ΓΕΝΕΡΑΛΙΣΜΕΝΗ STATE-SPACE AVERAGING ΣΤΟ DCM

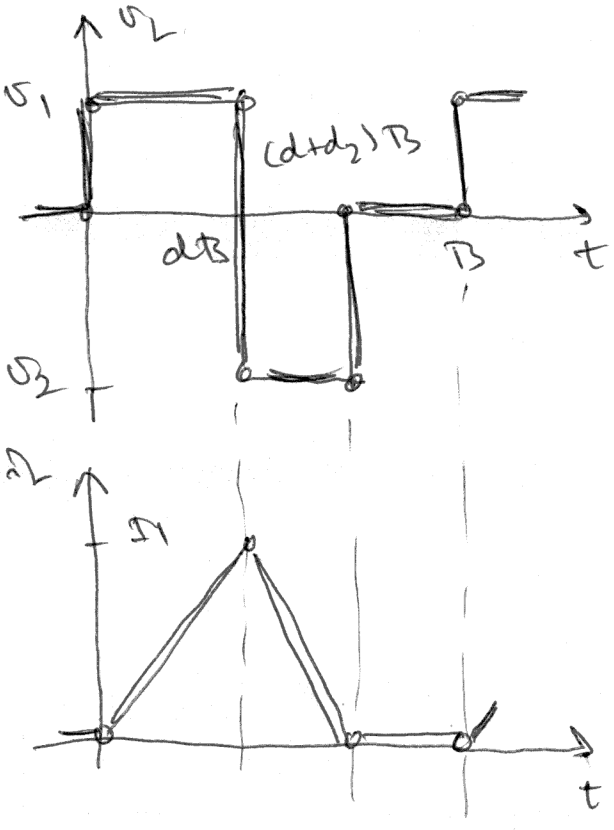
- STATE-SPACE AVERAGING ΧΩΡΙΣ RIPPLE
- RIPPLE IS ESSENTIAL IN THE DCM
- WHAT IS GOING ON?



$v_1 > 0$

$v_2 < 0$

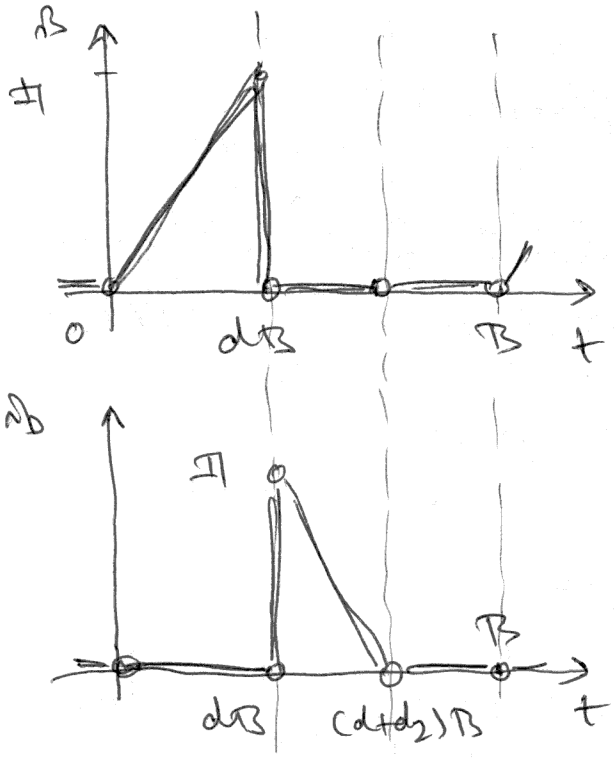
← "SWITCHING CELL"



$$\Delta i_1 = \frac{v_1}{L} dT_S$$

$$v_1 dT_S + v_2 d_2 T_S = 0$$

$$d_2 = -\frac{v_1}{v_2} d$$



ΔΑ ΝΟΜΙΖΟΥΜΕ $L\frac{d\vec{i}_L}{dt} = \vec{v}_L$

$$\vec{v}_L = \frac{1}{\Delta\Beta}\left(v_1 \cdot d\Delta\Beta + v_2 \cdot d_2\Delta\Beta\right) =$$

$$= v_1 d + v_2 d_2 = v_1 d - \frac{v_1}{v_2} d \cdot v_2 = 0$$

$$L\frac{d\vec{i}_L}{dt} = 0 \; ! \qquad \vec{i}_L = \text{const} \; !$$

ΑΠΣΥΡΣ, ΠΕΔΟΒΟΛΟΥΜΕ ΔΟΘΕΙΣ ΜΟΔΕΛ,

ΔΕΝ ΕΠΕΡΑΣΜΑ

Κοινώς σε $\bar{n}_2$?

$$\bar{n}_2 = \frac{1}{\cancel{T_s}} \cdot \frac{1}{2} (d\cancel{T_s} + d_2 \cancel{T_s}) I_1 =$$

$$= \frac{1}{2} (d + d_2) I_1 =$$

$$= \frac{1}{2} \left(d - \frac{v_1}{v_2} d\right) \frac{v_1}{L} dT_s =$$

$$= \frac{1}{2 f_s L} \left(1 - \frac{v_1}{v_2}\right) v_1 d^2$$

$$\boxed{\bar{n}_2 = \frac{1}{2 f_s L} \left(1 - \frac{v_1}{v_2}\right) v_1 d^2}$$

$$\bar{n}_3 = \frac{1}{\cancel{T_s}} \cdot \frac{1}{2} \cdot d\cancel{T_s} \cdot I_1 =$$

$$= \frac{1}{2} d I_1 =$$

$$= \frac{1}{2} d \frac{v_1}{L} \cdot d T_s =$$

$$= \frac{1}{2 f_s L} v_1 d^2$$

$$\boxed{\bar{n}_3 = \frac{1}{2 f_s L} v_1 d^2}$$

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$$\bar{i}_D = \frac{1}{I_B} \cdot \frac{1}{2} \cdot d_2 I_B \cdot I_1 =$$

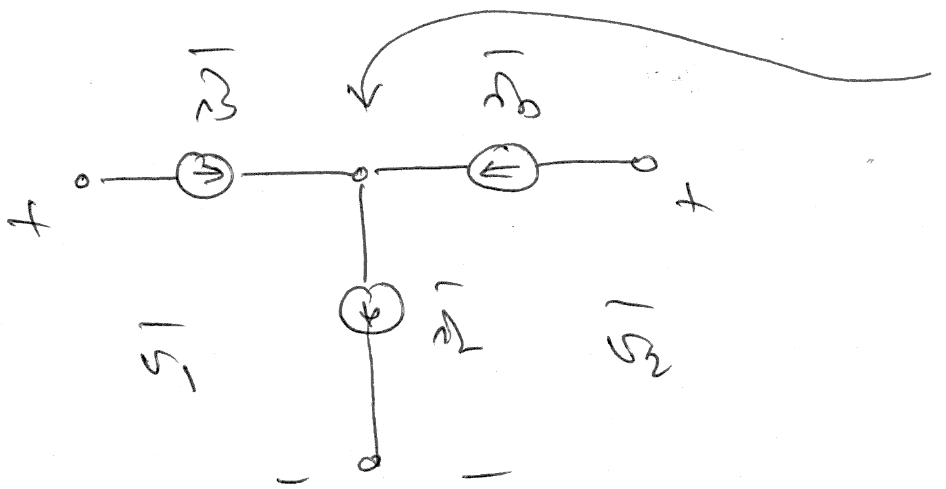
$$= \frac{1}{2} d_2 I_1 =$$

$$= \frac{1}{2} \left(-\frac{v_1}{v_2} d\right) \frac{v_1}{L} d T_s =$$

$$= \frac{1}{2 f_s L} \left(-\frac{v_1}{v_2}\right) d^2 v_1$$

$$\boxed{\bar{i}_D = \frac{1}{2 f_s L} \left(-\frac{v_1^2}{v_2}\right) d^2}$$

ΕΚΒΙΒΑΛΕΣΤΗΣ ΚΟΜΒΟΣ ?



ΠΡΟΒΛΗΜΑ!

- CURRENT SOURCE CUTSET
- $\bar{i}_L = \bar{i}_B + \bar{i}_D$ — INFINITELY MANY SOLUTIONS FOR THE CENTER NODE VOLTAGE!

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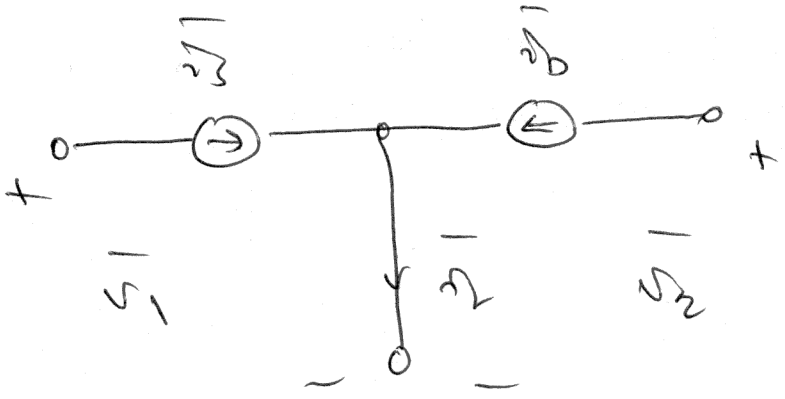
РЕШЕНИЕ:



$$\bar{i}_S = \frac{1}{2\beta\ell}\,\bar{v}_1 d^2$$

$$\bar{i}_D = -\frac{1}{2\beta\ell}\,\frac{\bar{v}_1^2}{\bar{v}_2}\,d^2$$

NONLINEAR!

LINEARIZE!

ОВО ЈЕ САСВИМ ДОВОЉНО; НЕЋУТИМ, ПОСТОЈИ И ФИЗИЧКА ИНТЕРПРЕТАЦИЈА:

$$\frac{\bar{v}_1}{\bar{i}_S} = \frac{2\beta\ell}{d^2} = R_e$$

СНАГА НА R_e ЈЕ

$$P_{Re} = \frac{d^2}{2\beta\ell}\,\bar{v}_1^{\,2} = \bar{i}_S\,\bar{v}_1$$

$$\bar{i}_D\,\bar{v}_2 = -\frac{d^2}{2\beta\ell}\,\bar{v}_1^{\,2} = -P_{Re}$$

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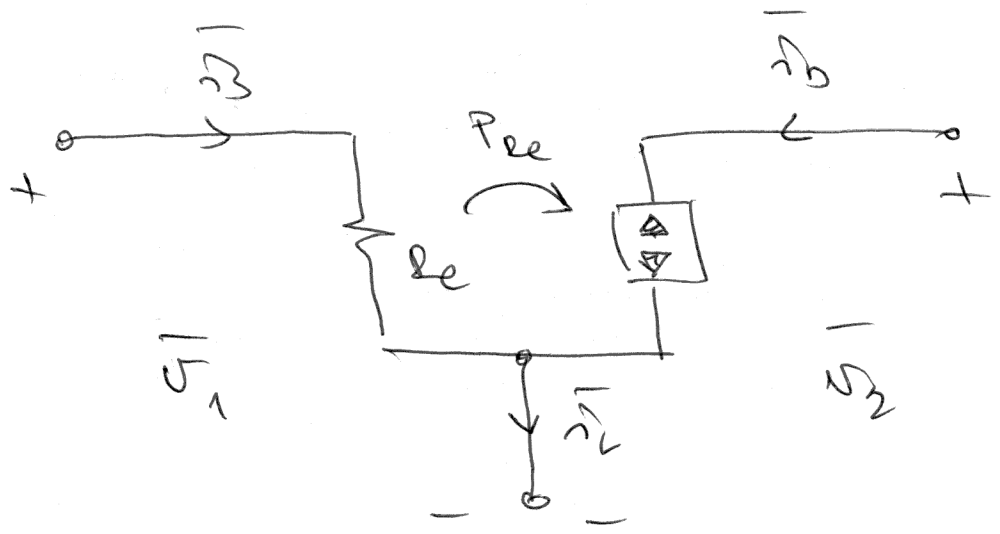
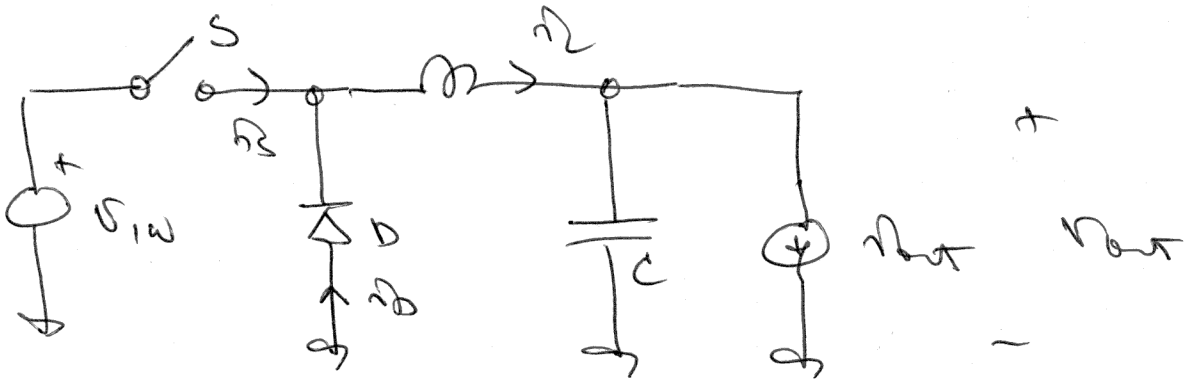
LOSS-FREE RESISTOR !

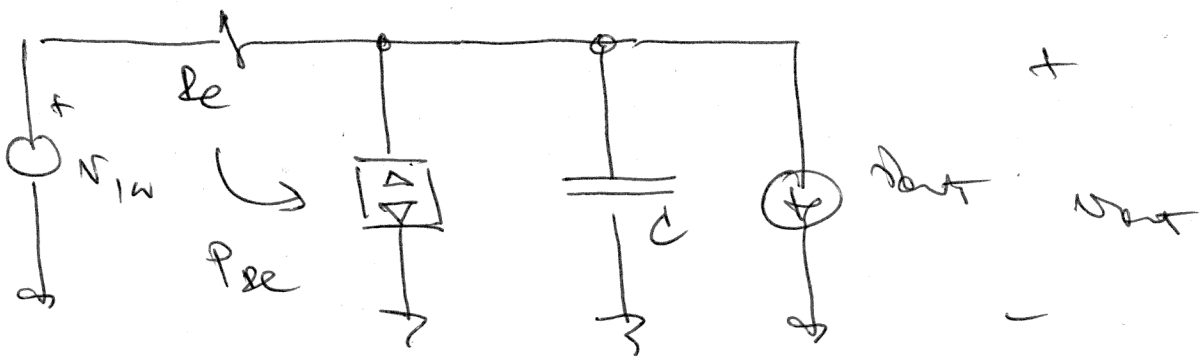


ESSENTIALLY, THE SAME THING, NOTHING NEW HERE ! JUST LOOKS BETTER, MARKETING !

ALL OF THE DCM EQUATIONS COULD BE DERIVED FROM HERE, FOR ALL OF THE CONVERTERS !

BUCK :





НА ПРИМЕР, ИЗЛАЗНА СТРУЈА БУСА КОНВЕРТОРА У DCM:

$$i_{out} = \frac{v_{IN} - v_{out}}{Re} + \frac{(v_{IN} - v_{out})^2}{Re} \cdot \frac{1}{v_{out}} =$$

$$= \frac{v_{IN} - v_{out}}{Re} \left(1 + \frac{v_{IN} - v_{out}}{v_{out}} \right) =$$

$$= \frac{v_{IN} - v_{out}}{Re} \cdot \frac{v_{out} + v_{IN} - v_{out}}{v_{out}} =$$

$$= \frac{v_{IN}}{Re} \cdot \frac{v_{IN} - v_{out}}{v_{out}} =$$

$$= \frac{d^2 v_{IN}}{2Re} \cdot \frac{v_{IN} - v_{out}}{v_{out}}$$

? ПОЗНАТО ЛИ ЕЕ1 ?

ОБРАЗЛОЖЕЊЕ ЈЕ МОГУЋЕ ЗА БИЛО КОЈИ ОД КОНВЕРТОРА !

ВАЖНО: КАКАВ ЈЕ ДОБРОДОШЛ МОДЕЛ ЗА SWITCHING CELL ? НЕЛИНЕАРАН, РЕДУКОВАН ! ДИРЕКТНА ПОСЛЕДИЦА АПЛИКАЦИЈЕ ДЕТЕКТОРАЦИЈЕ У DCM.

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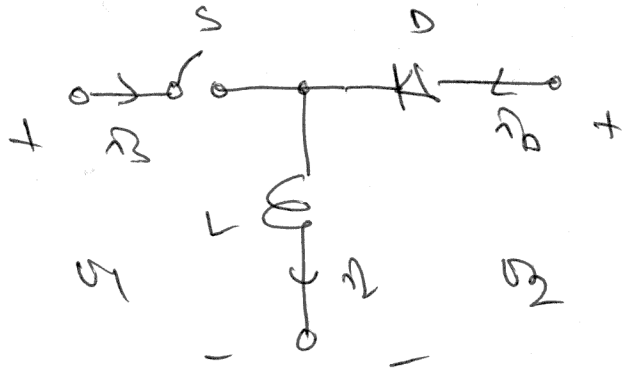
ΚΑΛΟ ΕΝ ΧΡΗΣΙΜΕΥΣΑΜΕ SWITCHING CELL ΜΟΔΕΛΟ ΣΕ CCM ?

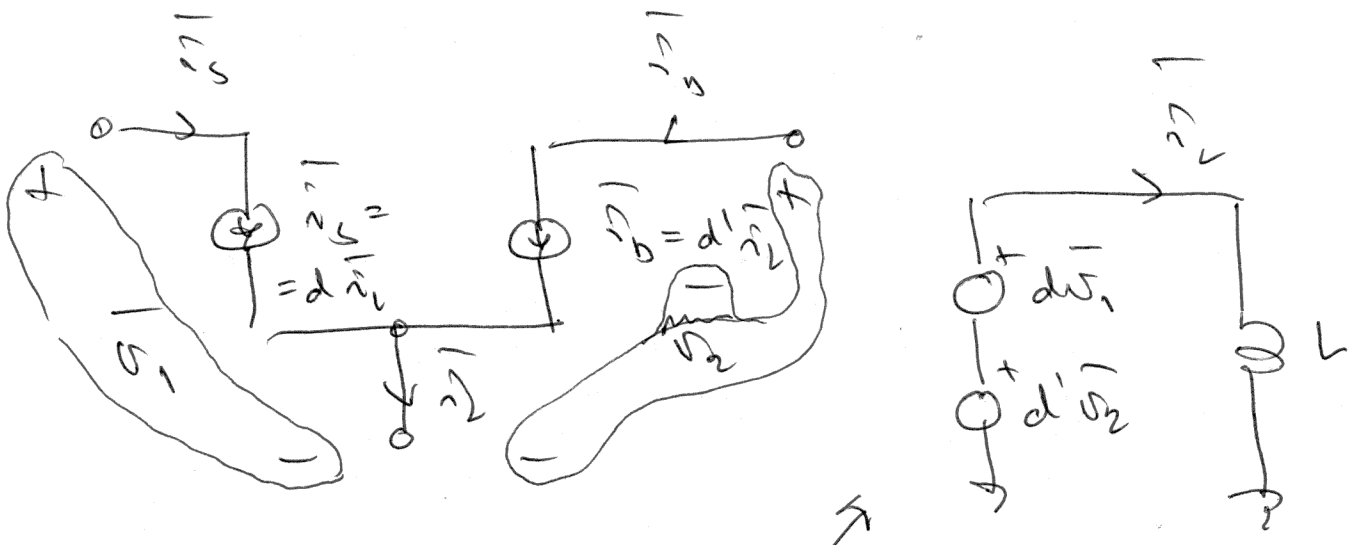


$$\bar{v}_L = L \frac{d\bar{i}_L}{dt} = d\,\bar{v}_1 + d'\,\bar{v}_2$$

$$\bar{i}_S = d\,\bar{i}_L$$

$$\bar{i}_D = d'\,\bar{i}_L$$

ΕΞΙΣΩΣΗΣΗ ΚΟΜΒΟΥ :



ΟΠΩΣΔΗΠΟΤΕ ΣΩΣΤΑ ! ΘΕΛΑΜΕ d' ΚΑΙ ΟΧΙ ΑΡΝΗΤΙΚΗ

$d_2 = -\frac{v_1}{v_2} d$, ΤΟ ΘΕΛΑΜΕ ΘΕΤΙΚΟ

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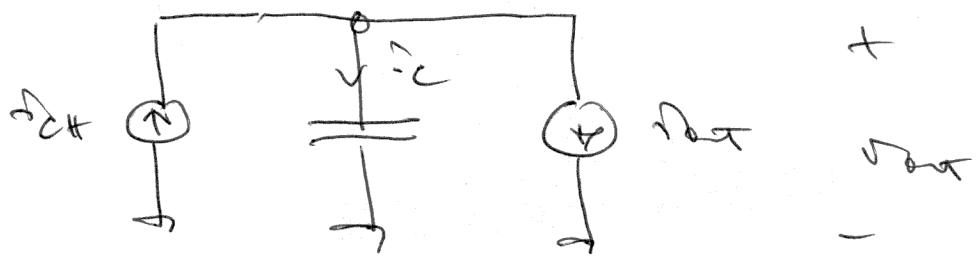
ΜΟΔΕΛΟ ΜΕΤΑΒΙΒΑΣΤΗΡΑ ⊃ DCM:



$i_{CH} = i_{CH}(V_1, V_2, d, 2\xi\delta L)$ ← ΑΛΓΕΒΡΑΪΚΑ ΒΕΒΑ, ΡΕΑΛΙΣΤΙΚΟ!

$i_C = i_{CH} - i_{out}$

$$C\frac{dv_{out}}{dt} = i_{CH} - i_{out}$$

ΜΟΔΕΛΟ ΣΕ ΠΡΩΤΗ ΡΕΖΑ!

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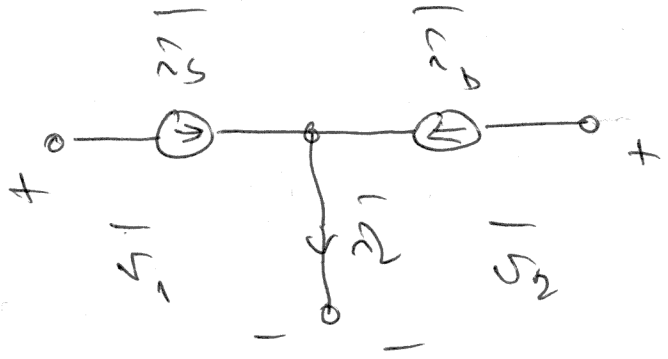
ΑΝΤΙΣΤΡΟΦΗ ΣΥΝΑΡΤΗΣΗ SWITCHING CELL



$$\bar{i}_s = \frac{1}{2fL}\,\bar{v}_1\,d^2$$

$$\bar{i}_D = -\frac{1}{2fL}\,\frac{\bar{v}_1^2}{\bar{v}_2}\,d^2$$

ΣΑΠΡΑΒΟ ↓ (≈)

$$\bar{i}_s = \frac{1}{2fL}\left(V_1 D_0^2 + D_0^2\,\hat{v}_1 + 2V_1 D_0\,\hat{d}\right)$$

$$I_s = \frac{1}{2fL}\,V_1 D_0^2$$

$$\hat{i}_s = \frac{1}{2fL}\left(D_0^2\,\hat{v}_1 + 2V_1 D_0\,\hat{d}\right)$$

$$\hat{i}_3 = \frac{D_0^2}{2fL}\,\hat{v}_1 + \frac{2V_1 D_0}{2fL}\,\hat{d}$$

$$\boxed{\hat{i}_3 = \frac{D_0^2}{2fL}\,\hat{v}_1 + \frac{V_1 D_0}{fL}\,\hat{d}}$$

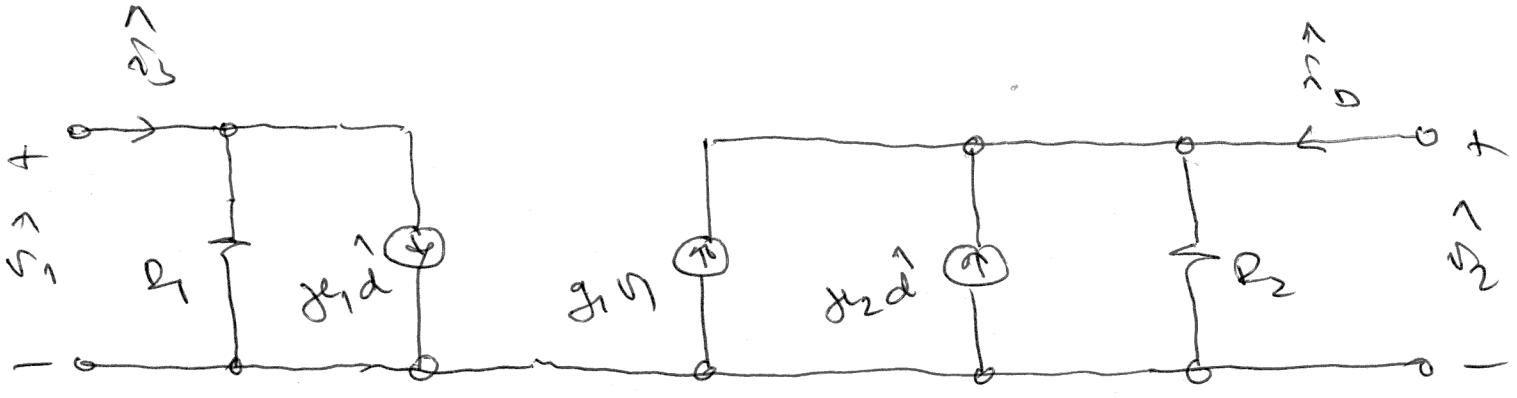
$$\hat{i}_D = -\frac{1}{2f_s L}\left(\frac{V_1^2}{V_2} D_0^2 + \frac{2V_1}{V_2} D_0^2 \hat{v}_1 + \right.$$

$$\left. + \frac{2V_1^2}{V_2} D_0 \hat{d} - \frac{V_1^2}{V_2^2} D_0^2 \hat{v}_2 \right)$$

$$I_D = -\frac{1}{2f_s L} \frac{V_1^2}{V_2} D_0^2$$

$$\hat{i}_D = -\frac{1}{2f_s L}\left(\frac{2V_1 D_0^2}{V_2} \hat{v}_1 + \frac{2V_1^2 D_0}{V_2} \hat{d} - \frac{V_1^2 D_0^2}{V_2^2} \hat{v}_2 \right)$$

$$\boxed{\hat{i}_D = -\frac{V_1 D_0^2}{f_s L V_2} \hat{v}_1 - \frac{V_1^2 D_0}{f_s L V_2} \hat{d} + \frac{V_1^2 D_0^2}{2 f_s L V_2^2} \hat{v}_2}$$



$$R_1 = \frac{2 f_s L}{D_0^2} \qquad g_1 = \frac{V_1 D_0^2}{f_s L V_2}$$

$$g_{d1} = \frac{V_1 D_0}{f_s L} \qquad g_{d2} = \frac{V_1^2 D_0}{f_s L V_2}$$

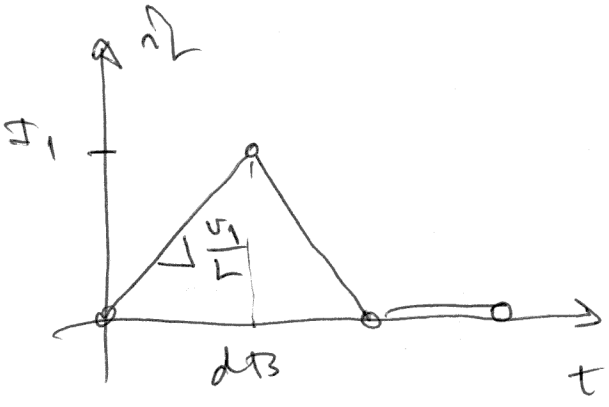
$$R_2 = \frac{2 f_s L V_2^2}{V_1^2 D_0^2}$$

RWE, AC RESISTORS,

ОВО ПОСТАЈЕ ПРЕВЕЛИКО КОМПЛИКОВАНО ЗА
РУЧНО РАЧУНАЊЕ, ИЗ Maxim ....

РЕЗУЛТУЈУЋЕ ТАЈМЕРЕ НА САЈТУ !

DCM, PEAK LIMITING CURRENT MODE CONTROL



$$I_1 = \frac{v_1}{L} \cdot d T_S$$

$$\boxed{d = \frac{f_s L I_1}{v_1}}$$

$$d = d(I_1) = \frac{f_s L}{v_1} I_1$$

ČEMU SAMO ZAMENA U RAČUNANJE