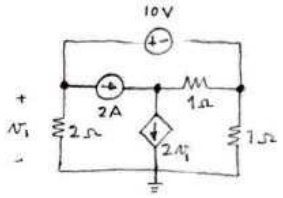
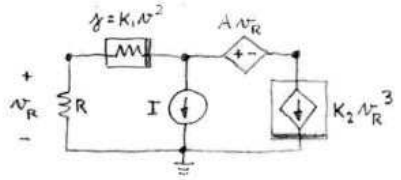
CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2000 1ª PROVA

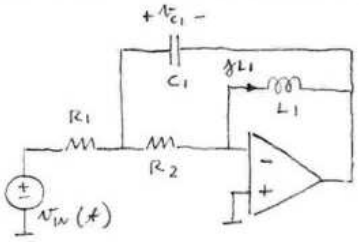
(1) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL, DIRETAMENTE EM FORMA MATRICIAL DESLOQUE FONTES DE TENSÃO. RESOLVA PARA AS TENSÕES NOS TRÊS NÓS ORIGINAIS.



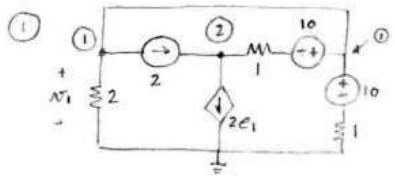
(2) PARA O CIRCUITO ABAIXO, MONTE O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APPROXIMAÇÃO PARA A SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON



(3) PARA O CIRCUITO ABAIXO, MONTE O SISTEMA NODAL QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$, CONHECIDA A SOLUÇÃO EM $t = t_0$, USANDO O MÉTODO DE EULER "BACKWARD". TRATE O AMP. OPERACIONAL EM UMA FORMA QUE REDUZA O TAMANHO DO SISTEMA A RESOLVER.



CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2000 - 1ª PROVA - GABARITO

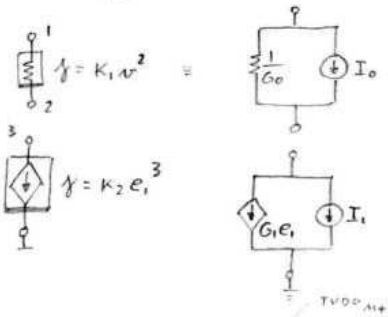
① 

$$\begin{bmatrix} \frac{1}{2}+1+1 & -1 \\ -1+2 & 1 \end{bmatrix}\begin{bmatrix} e_1 \\ e_3 \end{bmatrix} = \begin{bmatrix} -2+10+10 \\ 2-10 \end{bmatrix} \quad -2e_1 \quad \therefore \quad \begin{bmatrix} \frac{5}{2} & -1 \\ 1 & 1 \end{bmatrix}\begin{bmatrix} e_1 \\ e_2 \end{bmatrix} = \begin{bmatrix} 18 \\ -8 \end{bmatrix}$$

$$e_1 = \frac{18-8}{\frac{5}{2}+1} = \frac{10}{7/2} = +\frac{20}{7} \qquad e_2 = \frac{-\frac{5}{2}\times 8 - 18}{7/2} = \frac{-40-36}{7} = \frac{-76}{7}$$

$$e_3 = e_1 - 10 = \frac{20}{7} - 10 = \frac{20-70}{7} = -\frac{50}{7}$$

② MODELOS:

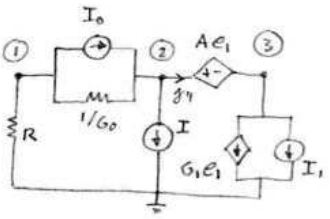


$G_0 = 2K_1(e_{1m} - e_{2m})$

$I_0 = K_1(e_{1m} - e_{2m})^2 - G_0(e_{1m} - e_{2m})$

$G_1 = 3K_2 e_{1m}^2$

$I_1 = K_2 e_{1m}^3 - G_1 e_{1m}$

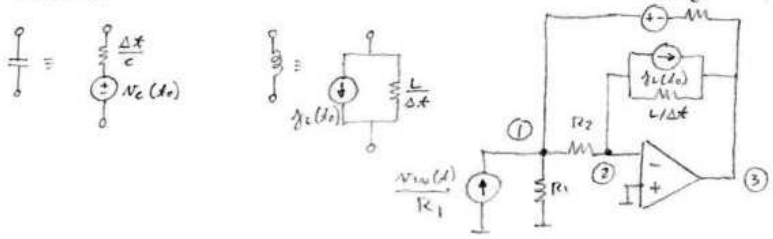


$e_2 - e_3 - Ae_1 = 0$

TVDP $M+1$

$$\begin{bmatrix} \frac{1}{R}+G_0 & -G_0 & 0 & 0 \\ -G_0 & G_0 & 0 & +1 \\ +G_1 & 0 & 0 & -1 \\ -A & +1 & -1 & 0 \end{bmatrix}\begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ v_1 \end{bmatrix} = \begin{bmatrix} -I_0 \\ +I_0 - I \\ -I_1 \\ 0 \end{bmatrix} \quad -G_1 e_1$$

③ MODELOS:



SEM O AMP-OP.:

$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2}+\frac{C}{\Delta t} & -\frac{1}{R_2} & -\frac{C}{\Delta t} \\ -\frac{1}{R_2} & \frac{1}{R_2}+\frac{\Delta t}{L} & -\frac{\Delta t}{L} \\ -\frac{C}{\Delta t} & -\frac{\Delta t}{L} & \frac{C}{\Delta t}+\frac{\Delta t}{L} \end{bmatrix}\begin{bmatrix} e_1 \\ e_2 \\ e_3 \end{bmatrix} = \begin{bmatrix} N_{fn}(I_0+\Delta I)/R_1 + \frac{N_C(I_0)C}{\Delta t} \\ -\gamma_L(I_0) \\ +\gamma_L(I_0) - \frac{N_C(I_0)C}{\Delta t} \end{bmatrix}$$

Reina

$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2}+\frac{C}{\Delta t} & -\frac{C}{\Delta t} \\ -\frac{1}{R_2} & -\frac{\Delta t}{L} \end{bmatrix}\begin{bmatrix} e_1(I_0+\Delta I) \\ e_3(I_0+\Delta I) \end{bmatrix} = \begin{bmatrix} N_{fn}(I_0+\Delta I)/R_1 + N_C(I_0)\frac{C}{\Delta t} \\ -\gamma_L(I_0) \end{bmatrix}$$

O AMP-OP. FAZ $e_2 = 0$ → ELIMINA-SE COLUNA 2

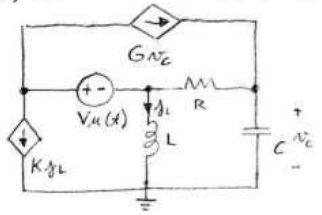
A 3ª EQUAÇÃO É DESNECESSÁRIA

CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2001 - 1ª PROVA 23/5/2001 BIAIUNOS

(1) PARA O CIRCUITO ABAIXO, ESCREVA: (ANÁLISE EM TRANSFORMADA DE LAPLACE)

a) UM SISTEMA NODAL MODIFICADO

b) UM SISTEMA NODAL PURO



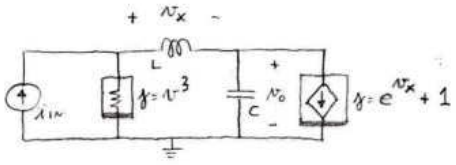
DADOS $i_L(0)$, $V_c(0)$

(2) PARA O CIRCUITO ABAIXO, DESCREVA, USANDO ANÁLISE NODAL:

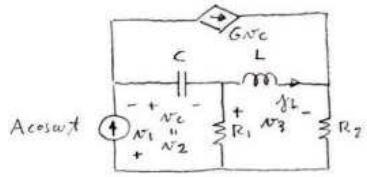
a) COMO OBTER O PONTO DE OPERAÇÃO. ACHE O PONTO DE OPERAÇÃO (POR INSPEÇÃO).

b) COMO OBTER A RESPOSTA EM FREQÜÊNCIA DE $\frac{V_0}{I_{IN}}$, PARA PEQUENOS SINAIS EM TORNO DO P.O.

ESCREVA OS SISTEMAS NODAIS NECESSÁRIOS NAS DUAS ANÁLISES.

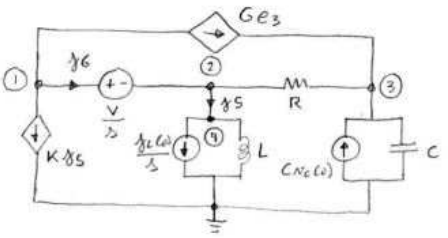


(3) ESCREVA UM SISTEMA PARA A ANÁLISE NO TEMPO DO CIRCUITO ABAIXO, ONDE AS INCÓGNITAS SÃO V_1, V_2 E V_3. VIA INTEGRAÇÃO B.E, CALCULANDO A SOLUÇÃO EM $t = t_0 + \Delta t$, DADOS $V_c(t_0)$ E $i_L(t_0)$



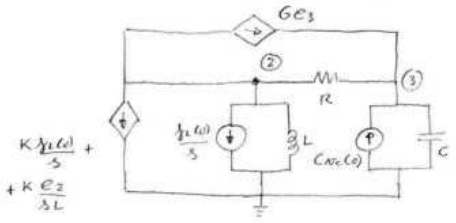
CIRCUITOS ELÉTRICOS II – 1º SEMESTRE DE 2001 – 1ª PROVA – GABARITO

(1)



$$\begin{bmatrix} 0 & 0 & +G & 0 & +K & +1 \\ 0 & \frac{1}{R} & -\frac{1}{R} & 0 & +1 & -1 \\ 0 & -\frac{1}{R} & sC+\frac{1}{R}-G & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{sL} & -1 & 0 \\ 0 & +1 & 0 & -1 & 0 & 0 \\ +1 & -1 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ e_4 \\ i_3 \\ i_6 \end{bmatrix} = \begin{bmatrix} -Ge_3 \\ 0 \\ CV_C(0)+Ge_3 \\ -\frac{i_L(0)}{s} \\ 0 \\ \frac{V}{s} \end{bmatrix}$$

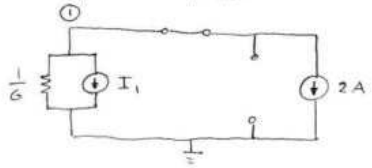
DESLOCANDO A FONTE $\frac{V}{s}$ NA DIREÇÃO DAS FONTES DE CORRENTE ELA DESAPARECE, E RECAÍ NO TRADICIONAL



$$\begin{bmatrix} \frac{1}{sL}+\frac{1}{R}+\frac{K}{sL} & -\frac{1}{R}+G \\ -\frac{1}{R} & \frac{1}{R}+sC-G \end{bmatrix} \begin{bmatrix} e_2 \\ e_3 \end{bmatrix} = \begin{bmatrix} -K\frac{i_L(0)}{s} - K\frac{e_2}{sL} - Ge_3 - \frac{i_L(0)}{s} \\ Ge_3 + CV_C(0) \end{bmatrix}$$

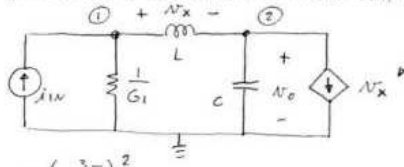
(2) PARA ACHAR O P.O., FAZER $\dot{x}_{IN}=0$ E ITERAR: $[G]\,e_{i\,m+1} = [-I_1 - 2]$

COM: $\begin{cases} G_1 = 3e_{iM}^2 \\ I_1 = e_{iM}^3 - G_1 e_{iM} \end{cases}$ (A FONTE CONTROLADA É CONSTANTE, POIS $N_x=0$ $\therefore$ 2 A)



A SOLUÇÃO FINAL É $-2 = e_1^3 \;\therefore\; e_1 = -\sqrt[3]{2}$

PARA ACHAR A RESPOSTA EM FREQUÊNCIA BASTA RESOLVER O CIRCUITO EM $j\omega$, PARA A FAIXA DE ω DESEJADA:

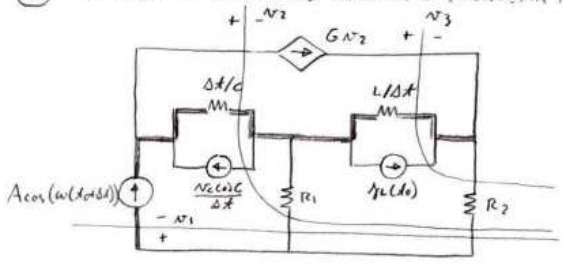


A TRANSCONDUTÂNCIA É e^{N_x} COM $N_x = 0$, OU $1\ \mho$

$$\begin{bmatrix} G_1 + \frac{1}{j\omega L} & -\frac{1}{j\omega L} \\ -\frac{1}{j\omega L}+1 & \frac{1}{j\omega L}+j\omega C-1 \end{bmatrix} \begin{bmatrix} e_1(j\omega) \\ e_2(j\omega) \end{bmatrix} = \begin{bmatrix} i_{IN} \\ -(e_1-e_2) \end{bmatrix} \qquad N_o = e_2$$

$$G_1 = 3\left(-\sqrt[3]{2}\right)^2$$

(3) UM SISTEMA DE CONTAS RESOLVE O PROBLEMA:

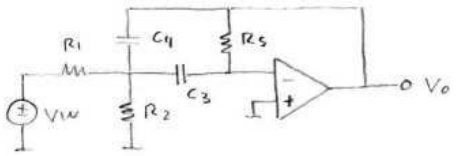


$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_2} & \frac{1}{R_1}+\frac{1}{R_2} & \frac{1}{R_2} \\ \frac{1}{R_1}+\frac{1}{R_2} & \frac{C}{\Delta t}+\frac{1}{R_1}+\frac{1}{R_2}+G & \frac{1}{R_2} \\ \frac{1}{R_2} & \frac{1}{R_2}+G & \frac{\Delta t}{L}+\frac{1}{R_2} \end{bmatrix} \begin{bmatrix} N_1 \\ N_2 \\ N_3 \end{bmatrix} =$$

$$= \begin{bmatrix} -A\cos(\omega(t_0+\Delta t)) \\ +\frac{N_C(t_0)C}{\Delta t} - GN_2 \\ -i_L(t_0) - GN_2 \end{bmatrix}$$

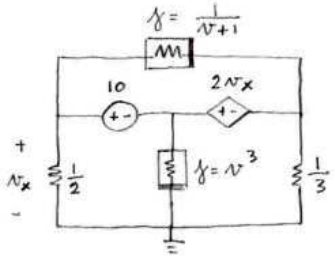
CIRCUITOS ELÉTRICOS II - 1ª PROVA - 1º SEMESTRE DE 2003

(1)



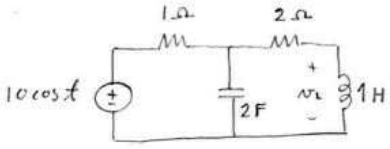
ACHE $\frac{V_o}{V_{IN}}(s)$ USANDO UMA ANÁLISE NODAL

(2)



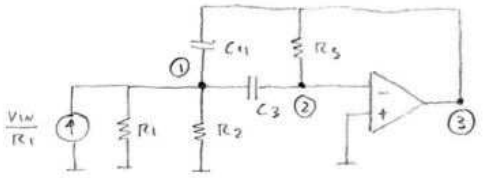
ESCREVA O SISTEMA NODAL MODIFICADO QUE ACHA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO DO CIRCUITO, SOMANDO A SOLUÇÃO ATUAL COM TODAS AS TRANSFERÊNCIAS CONDUTÂNCIAS NULAS

(3)



USE UM SISTEMA DE MALHAS PARA ACHAR A TENSÃO SOBRE O INDUTOR NO ESTADO PERMANENTE SENOIDAL

CIRCUITOS ELÉTRICOS II – 1ª PROVA – 1º SEMESTRE DE 2003 – GABARITO 27 ALUNOS + 1

① 

$$\xrightarrow{SA1} \begin{bmatrix} sC_4+sC_3+\frac{1}{R_1}+\frac{1}{R_2} & -sC_3 & -sC_4 \\ -sC_3 & \frac{1}{R_3}+sC_3 & -\frac{1}{R_3} \\ -sC_4 & -\frac{1}{R_3} & \frac{1}{R_3}+sC_4 \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix} = \begin{bmatrix} \frac{V_{in}}{R_1} \\ 0 \\ 0 \end{bmatrix}$$

$E_2 = 0$ (SA1)

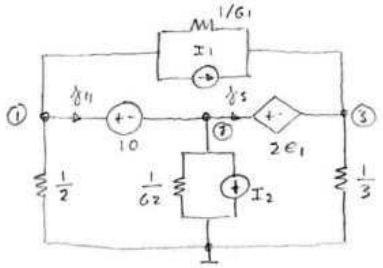
$$\begin{bmatrix} sC_3+sC_4+\frac{1}{R_1}+\frac{1}{R_2} & -sC_4 \\ -sC_3 & -\frac{1}{R_3} \end{bmatrix} \begin{bmatrix} E_1 \\ E_3 \end{bmatrix} = \begin{bmatrix} \frac{V_{in}}{R_1} \\ 0 \end{bmatrix}$$

$$\frac{E_3}{V_{in}} = \frac{+\frac{sC_3}{R_1}}{-\frac{sC_3}{R_3}-\frac{sC_4}{R_3}-\frac{1}{R_1R_3}-\frac{1}{R_2R_3}-s^2C_3C_4}$$

$\div\, C_3C_4$ (FACTOR DE ESCALA)

$$\frac{V_o}{V_{in}} = \frac{-s\frac{1}{R_1C_4}}{s^2+s\left(\frac{1}{R_3C_4}+\frac{1}{R_3C_3}\right)+\frac{1}{C_3C_4R_3}\left(\frac{1}{R_1}+\frac{1}{R_3}\right)}$$

FILTRO PASSA-FAIXA DE 2ª ORDEM (AMPLIFICADOR)

② 

$G_1 = -\frac{1}{(V_{n1}+1)^2} = -1$

$I_1 = \frac{1}{V_{n1}+1} - GV_{n1} = 1+1\times 0 = 1$

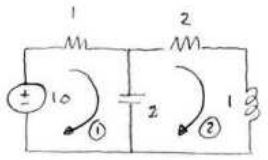
$G_2 = 3V_{n1}^2 = 0$

$I_2 = V_3^3 - G_2V_{n1} = 0 - 0\times 0 = 0$

$e_1 - e_2 = 10$

$e_2 - e_3 = 2e_1$

$$\begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{bmatrix} 2-1 & 0 & +1 & +1 & 0 \\ 0 & 0 & 0 & -1 & +1 \\ +1 & 0 & 3-1 & 0 & -1 \\ +1 & -1 & 0 & 0 & 0 \\ -2 & +1 & -1 & 0 & 0 \end{bmatrix} \begin{bmatrix} e_{1,n+1} \\ e_{2,n+1} \\ e_{3,n+1} \\ J_{4,n+1} \\ J_{5,n+1} \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \\ +1 \\ 10 \\ 0 \end{bmatrix}$$

③ 

MAIS FÁCIL FAZER EM s (?)

$$\begin{bmatrix} 1+\frac{1}{2s} & -\frac{1}{2s} \\ -\frac{1}{2s} & \frac{1}{2s}+2+s \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \end{bmatrix}$$

$$I_2 = \frac{+\frac{5}{s}}{\frac{1}{2s}+2+s+\frac{1}{4s^2}+\frac{1}{s}+\frac{1}{2}-\frac{1}{4s^2}} = \frac{+\frac{5}{s}}{\frac{3}{2}\frac{1}{s}+s+\frac{5}{2}} \overset{\times 2s}{=} \frac{+10}{3+2s^2+5s} \quad \therefore V_L = \frac{+10s}{2s^2+5s+3}$$

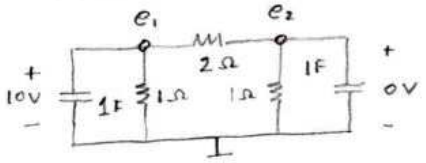
com $s = j$:

$$V_L = \frac{+10j}{-2+5j+3} = \frac{+10j}{1+5j} = \frac{+10j(1-5j)}{26} = +\frac{50}{26}+\frac{10j}{26}$$

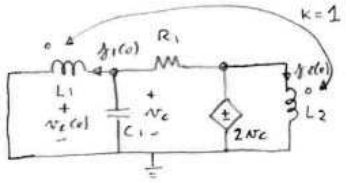
$$v_L(t) = +\frac{50}{26}\cos t - \frac{10}{26}\operatorname{sen} t \qquad v_L = \frac{10}{\sqrt{26}}\cos\left(t+\tan^{-1}\frac{1}{5}\right)$$

CIRCUITOS ELÉTRICOS II 1º SEMESTRE DE 2004 1ª PROVA 14/5/2004

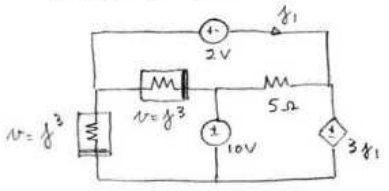
(1) PARA O CIRCUITO ABAIXO, CALCULE $e_1(t)$ E $e_2(t)$, A PARTIR DE UM SISTEMA NODAL EM TRANSFORMADA DE LAPLACE, DADO O ESTADO EM $t = 0$:



(2) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA $\vec{e}(t_0+\Delta t)$, DADO O ESTADO DO CIRCUITO EM $t = t_0$, USANDO A APROXIMAÇÃO "BACKWARD" DE EULER

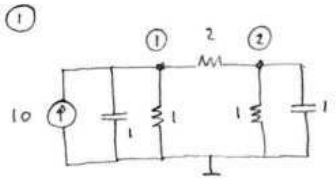


(3) ESCREVA UM SISTEMA DE MALHAS QUE CALCULE A PRÓXIMA APROXIMAÇÃO DE $\vec{x}$ PELO MÉTODO DE NEWTON-RAPHSON



CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2004 - 1ª PROVA - GABARITO

(1)



$$\begin{bmatrix} s+1+0.5 & -0.5 \\ -0.5 & s+1+0.5 \end{bmatrix} \begin{bmatrix} E_1(s) \\ E_2(s) \end{bmatrix} = \begin{bmatrix} 10 \\ 0 \end{bmatrix}$$

$$E_1(s) = \frac{10(s+1.5)}{(s^2+3s+1.5^2)-0.5^2} = \frac{10(s+1.5)}{s^2+3s+2} = \frac{10s+15}{(s+1)(s+2)}$$

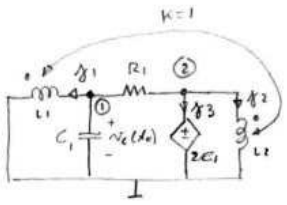
$$= \frac{A_1}{s+1} + \frac{A_2}{s+2} \qquad A_1 = \left.\frac{10s+15}{s+2}\right|_{s=-1} = \frac{-10+15}{-1+2} = 5 \qquad A_2 = \left.\frac{10s+15}{s+1}\right|_{s=-2} = \frac{-20+15}{-2+1} = 5$$

$$e_1(t) = 5e^{-t} + 5e^{-2t}$$ COMEÇA DE 10, ACABA EM 0

$$E_2(s) = \frac{+5}{(s+1)(s+2)} = \frac{A_1}{s+1} + \frac{A_2}{s+2} \qquad A_1 = \left.\frac{5}{s+2}\right|_{s=-1} = 5 \qquad A_1 = \left.\frac{5}{s+1}\right|_{s=-2} = -5$$

$$e_2(t) = 5e^{-t} - 5e^{-2t}$$ COMEÇA E ACABA EM 0

(2)

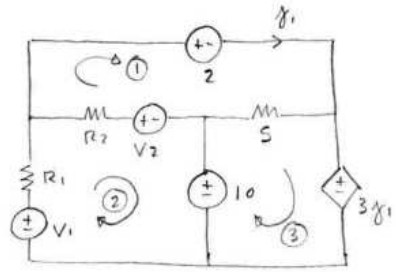


$$\begin{array}{c|cc|ccc} & e_1 & e_2 & y_1 & y_2 & y_3 \\ \hline & \frac{C_1}{\Delta t}+1/R_1 & -1/R_1 & +1 & 0 & 0 \\ & -1/R_1 & 1/R_1 & 0 & +1 & +1 \\ \hline & -1 & 0 & \frac{L_1}{\Delta t} & -\frac{M}{\Delta t} & 0 \\ & 0 & -1 & -\frac{M}{\Delta t} & \frac{L_2}{\Delta t} & 0 \\ & -2 & 1 & 0 & 0 & 0 \end{array} \begin{bmatrix} e_1(t_0+\Delta t) \\ e_2(t_0+\Delta t) \\ y_1(t_0+\Delta t) \\ y_2(t_0+\Delta t) \\ y_3(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} \frac{C_1}{\Delta t} v_c(t_0) \\ 0 \\ \frac{L_1}{\Delta t} y_1(t_0) - \frac{M}{\Delta t} y_2(t_0) \\ -\frac{M}{\Delta t} y_1(t_0) + \frac{L_2}{\Delta t} y_2(t_0) \\ 0 \end{bmatrix}$$

TRANSFORMADOR:

$$\vec{y}(t_0+\Delta t) = \vec{y}(t_0) + [\Gamma]\Delta t \vec{v}(t_0+\Delta t) \quad \therefore -\vec{v}(t_0+\Delta t) + \frac{1}{\Delta t}[L]\vec{y}(t_0+\Delta t) = \frac{1}{\Delta t}[L]\vec{y}(t_0) \qquad M = K\sqrt{L_1 L_2} = \sqrt{L_1 L_2}$$

(3)

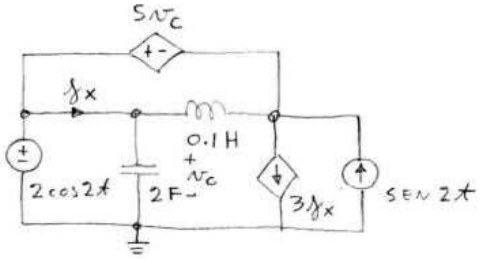


$$R_1 = 3(-i_{2m})^2$$
$$V_1 = (-i_{2m})^3 - R_1(-i_{2m})$$
$$R_2 = 3(i_{2m}-i_{1m})^2$$
$$V_2 = (i_{2m}-i_{1m})^3 - R_2(i_{2m}-i_{1m})$$

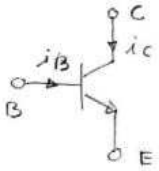
$$\begin{bmatrix} R_2+5 & -R_2 & -5 \\ -R_2 & R_1+R_2 & 0 \\ -5+3 & 0 & 5 \end{bmatrix} \begin{bmatrix} i_{1m+1} \\ i_{2m+1} \\ i_{3m+1} \end{bmatrix} = \begin{bmatrix} V_2-2 \\ V_1-V_2-10 \\ 10-3i_1 \end{bmatrix}$$

CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2005 - 1ª PROVA 29/11/2005

(1) ESCREVA O SISTEMA NODAL MODIFICADO PARA ANÁLISE DO CIRCUITO, NO ESTADO PERMANENTE SENOIDAL



(2) MOSTRE COMO FICA A ESTAMPA EM UM SISTEMA DE EQUAÇÕES NODAIS DE UM TRANSISTOR MODELADO PELO MODELO HÍBRIDO π PARA PEQUENOS SINAIS

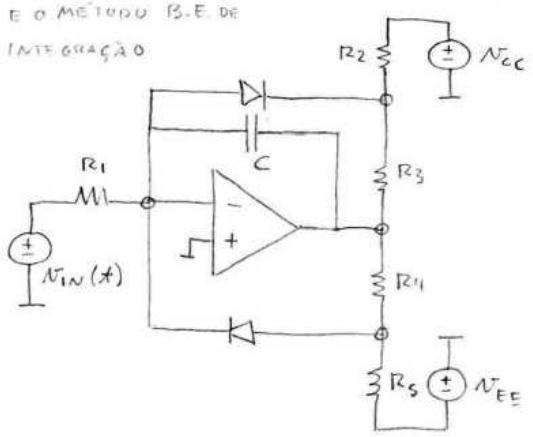


$$v_{BE} = h_{ie}\, i_B + h_{re}\, v_{CE}$$

$$i_C = h_{fe}\, i_B + h_{oe}\, v_{CE}$$

O MODELO DEVE TER 3 NÓS, E APENAS ELEMENTOS PERMITIDOS NA ANÁLISE NODAL

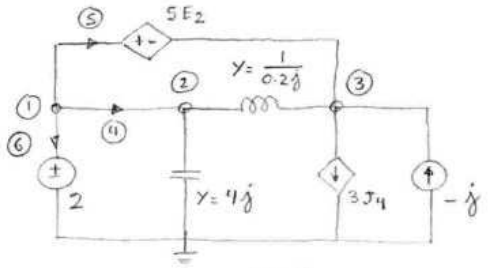
(3) ESCREVA O SISTEMA NODAL QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO DO CIRCUITO EM $t = t_0 + \Delta t$ PELO MÉTODO DE NEWTON-RAPHSON USANDO REDUÇÃO DO TAMANHO DO SISTEMA DEVIDO AO AMP. OP. IDEAL E O MÉTODO B.E. DE INTEGRAÇÃO



DIODOS: $y = I_S\left(e^{v/Vt} - 1\right)$

CIRCUITOS ELÉTRICOS II – 1º SEMESTRE DE 2005 – 1ª PROVA – GABARITO 15 ALUNOS

(1)



$$\begin{bmatrix} 0 & 0 & 0 & +1 & +1 & +1 \\ 0 & 4j-5j & +5j & -1 & 0 & 0 \\ 0 & +5j & -5j & +3 & -1 & 0 \\ -1 & +1 & 0 & 0 & 0 & 0 \\ -1 & +5 & +1 & 0 & 0 & 0 \\ +1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ J_4 \\ J_5 \\ J_6 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ -j \\ 0 \\ 0 \\ +2 \end{bmatrix}$$

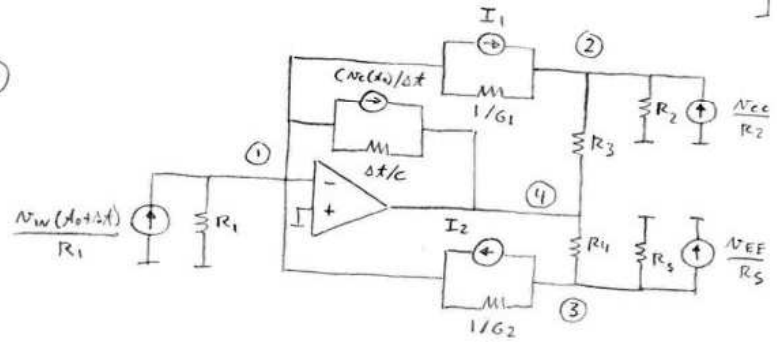
(2) $V_{BE} = h_{ie} i_B + h_{re} V_{CE} \;\therefore\; i_B = \frac{V_{BE}}{h_{ie}} - \frac{h_{re}}{h_{ie}} V_{CE}$

$$i_C = \frac{h_{fe}}{h_{ie}} V_{BE} - h_{fe}\frac{h_{re}}{h_{ie}} V_{CE} + h_{oe} V_{CE} = \frac{h_{fe}}{h_{ie}} V_{BE} + \left(h_{oe} - h_{fe}\frac{h_{re}}{h_{ie}}\right) V_{CE}$$

$G = \frac{1}{R}$

$$\begin{bmatrix} +G & \frac{h_{fe}}{h_{ie}} & -\frac{h_{fe}}{h_{ie}} - G \\ -\frac{h_{re}}{h_{ie}} & \frac{1}{h_{ie}} & -\frac{1}{h_{ie}} + \frac{h_{re}}{h_{ie}} \\ +\frac{h_{re}}{h_{ie}} - G & -\frac{1}{h_{ie}} - \frac{h_{fe}}{h_{ie}} & +\frac{1}{h_{ie}} + \frac{h_{fe}}{h_{ie}} + G - \frac{h_{re}}{h_{ie}} \end{bmatrix} \begin{bmatrix} e_C \\ e_B \\ e_E \end{bmatrix} = \begin{bmatrix} \\ \\ \end{bmatrix}$$

(3)



usando $\vec{e}_m(t_0+\Delta t)$:

$$G_1 = \frac{I_S}{V_T} e^{\frac{e_{1m}-e_{2m}}{V_T}}$$

$$I_1 = I_S\left(e^{\frac{e_{1m}-e_{2m}}{V_T}} - 1\right) - G_1(e_{1m}-e_{2m})$$

$$G_2 = \frac{I_S}{V_T} e^{\frac{e_{2m}-e_{1m}}{V_T}}$$

$$I_2 = I_S\left(e^{\frac{e_{3m}-e_{1m}}{V_T}} - 1\right) - G_2(e_{3m}-e_{1m})$$

$$\begin{bmatrix} \frac{1}{R_1} + \frac{C}{\Delta t} + G_1 + G_2 & -G_1 & -G_2 & -\frac{C}{\Delta t} \\ -G_1 & G_1 + \frac{1}{R_3} + \frac{1}{R_2} & 0 & -\frac{1}{R_3} \\ -G_2 & 0 & G_2 + \frac{1}{R_4} + \frac{1}{R_5} & -\frac{1}{R_4} \\ -\frac{C}{\Delta t} & -\frac{1}{R_3} & -\frac{1}{R_4} & \frac{C}{\Delta t} + \frac{1}{R_3} + \frac{1}{R_4} \end{bmatrix} \begin{bmatrix} e^{0}_{1_{M+1}}(t_0+\Delta t) \\ e_{2_{M+1}}(t_0+\Delta t) \\ e_{3_{M+1}}(t_0+\Delta t) \\ e_{4_{M+1}}(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} \frac{V_{in}(t_0+\Delta t)}{R_1} - \frac{C\,V_C(t_0)}{\Delta t} \\ -I_1 + I_2 \\ I_1 + \frac{V_{CC}}{R_2} \\ -I_2 - \frac{V_{EE}}{R_5} \\ \frac{C\,V_C(t_0)}{\Delta t} \end{bmatrix}$$

SAI →

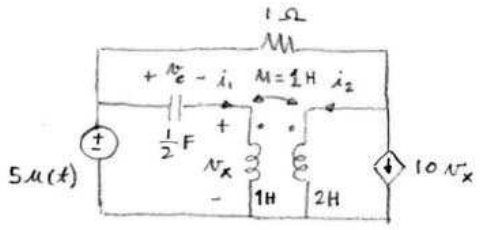
SAI ↑

RESTA:

$$\begin{bmatrix} -G_1 & -G_2 & -\frac{C}{\Delta t} \\ G_1 + \frac{1}{R_3} + \frac{1}{R_2} & 0 & -\frac{1}{R_3} \\ 0 & G_2 + \frac{1}{R_4} + \frac{1}{R_5} & -\frac{1}{R_4} \end{bmatrix} \begin{bmatrix} e_2 \\ e_3 \\ e_4 \end{bmatrix} = \begin{bmatrix} \frac{V_{in}(t_0+\Delta t)}{R_1} - \frac{C\,V_C(t_0)}{\Delta t} - I_1 + I_2 \\ I_1 + \frac{V_{CC}}{R_2} \\ -I_2 - \frac{V_{EE}}{R_5} \end{bmatrix}$$

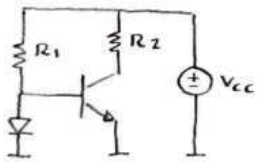
CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2006 - 1ª PROVA

(1) ESCREVA O SISTEMA NODAL MODIFICADO QUE RESOLVE O CIRCUITO USANDO TRANSFORMADA DE LAPLACE



DADOS $v_c(0)$, $i_1(0)$ E $i_2(0)$

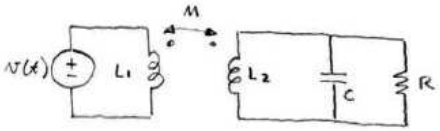
(2) MOSTRE COMO RESOLVER O CIRCUITO USANDO ANÁLISE NODAL E O MÉTODO DE NEWTON-RAPHSON. ESCREVENDO O SISTEMA DE EQUAÇÕES USADO NO MÉTODO.



DIODO: $i_d = I_s\left(e^{v_d/V_t} - 1\right)$

TRANSISTOR: MODELO DE EBERS-MOLL

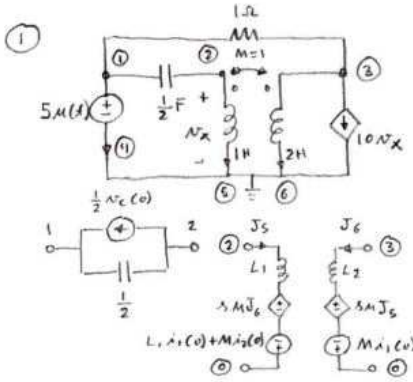
(3) ESCREVA O SISTEMA DE MALHAS QUE CALCULA A SOLUÇÃO DO CIRCUITO EM $t = t_0 + \Delta t$, USANDO INTEGRAÇÃO BACKWARD DE EULER



ENCONTRE UMA FORMA DE COMBINAR C E R, DE FORMA A GERAR UM SISTEMA COM APENAS DUAS MALHAS (EQUIVALENTE THÉVENIN)

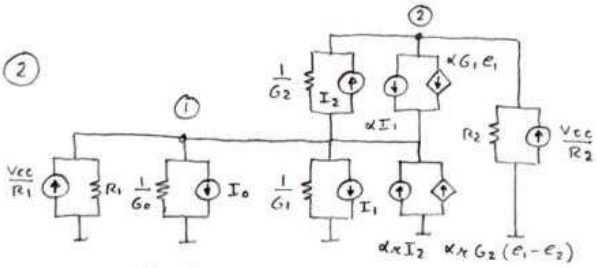
CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2006 - 1ª PROVA 20/10/2006 13 ALUNOS

(1)



$$\begin{bmatrix} \frac{1}{2}s+1 & -\frac{1}{2}s & -1 & +1 & 0 & 0 \\ -\frac{1}{2}s & \frac{1}{2}s & 0 & 0 & +1 & 0 \\ -1 & 10 & 1 & 0 & 0 & +1 \\ -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 & sL_1 & sM \\ 0 & 0 & -1 & 0 & sM & sL_2 \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ J_4 \\ J_5 \\ J_6 \end{bmatrix} = \begin{bmatrix} \frac{1}{2}N_c(0) \\ -\frac{1}{2}N_c(0) \\ 0 \\ -\frac{5}{s} \\ L_1 i_1(0) + M i_2(0) \\ M i_1(0) + L_2 i_2(0) \end{bmatrix}$$

(2)



$$G_0 = \frac{I_S}{Vt} e^{e_{1M}/Vt}$$

$$I_0 = I_S \left(e^{e_{1M}/Vt} - 1 \right) - G_0 e_{1M}$$

$$G_1 = G_0 \qquad I_1 = I_0$$

$$G_2 = \frac{I_S}{Vt} e^{(e_{1M}-e_{2M})/Vt}$$

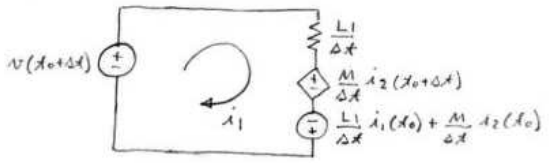
$$I_2 = I_S \left(e^{(e_{1M}-e_{2M})/Vt} - 1 \right) - G_2 (e_{1M} - e_{2M})$$

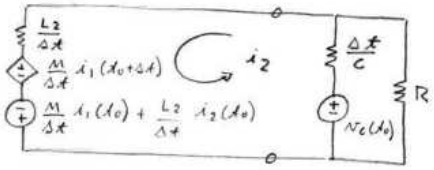
$$\begin{bmatrix} \frac{1}{R_1} + G_0 + G_1 + G_2 - \alpha G_1 - \alpha_x G_2 & -G_2 + \alpha_x G_2 \\ -G_2 + \alpha G_1 & \frac{1}{R_2} + G_2 \end{bmatrix} \begin{bmatrix} e_{1\,M+1} \\ e_{2\,M+1} \end{bmatrix}$$

$$\begin{bmatrix} \frac{Vcc}{R_1} - I_0 - I_1 + \alpha_x I_2 - I_2 + \alpha I_1 + \alpha_x G_2 (e_{1_{M+1}} - e_{2_{M+1}}) + \alpha G_1 e_{1_{M+1}} \\ \frac{Vcc}{R_2} + I_2 - \alpha I_1 - \alpha G_1 e_{1_{M+1}} \end{bmatrix}$$

CALCULA-SE OS VALORES À ESQUERDA, E RESOLVE-SE O SISTEMA.
NA PRIMEIRA VEZ, $\vec{e}_M$ É UMA APROXIMAÇÃO INICIAL.
NAS VEZES SEGUINTES É A ÚLTIMA SOLUÇÃO.
ITERA-SE ATÉ $\vec{e}_{M+1} \approx \vec{e}_M$.

(3)





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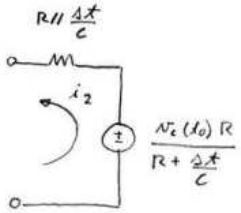


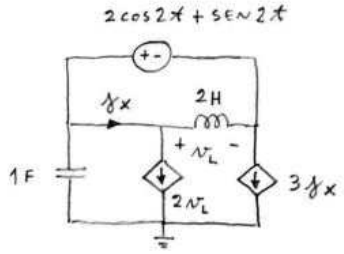
ASSIM REC FICAM COMBINADOS

$$\begin{bmatrix} \frac{L_1}{\Delta t} & \frac{M}{\Delta t} \\ \frac{M}{\Delta t} & \frac{L_2}{\Delta t} + R // \frac{\Delta t}{C} \end{bmatrix} \begin{bmatrix} i_1(t_0+\Delta t) \\ i_2(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} V(t_0+\Delta t) + \frac{L_1}{\Delta t} i_1(t_0) + \frac{M}{\Delta t} i_2(t_0) \\ \frac{M}{\Delta t} i_1(t_0) + \frac{L_2}{\Delta t} i_2(t_0) + \frac{N_c(t_0) R}{R + \frac{\Delta t}{C}} \end{bmatrix}$$

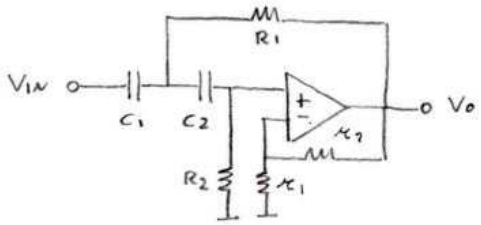
$N_c(t_0+\Delta t)$ É CALCULADA COMO $N_c(t_0+\Delta t) = N_c(t_0) \frac{R}{R+\frac{\Delta t}{C}} - R // \frac{\Delta t}{C} i_2(t_0+\Delta t)$

CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2007 - 1ª PROVA

(1) ESCREVA O SISTEMA NODAL MODIFICADO QUE RESOLVE O CIRCUITO, NO ESTADO PERMANENTE SENOIDAL



(2) ACHE A FUNÇÃO DE TRANSFERÊNCIA $\frac{V_o}{V_{IN}}(s)$ USANDO UMA ANÁLISE NODAL COM ELIMINAÇÃO DO AMP. OP.

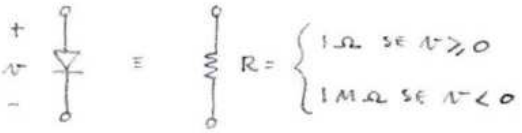


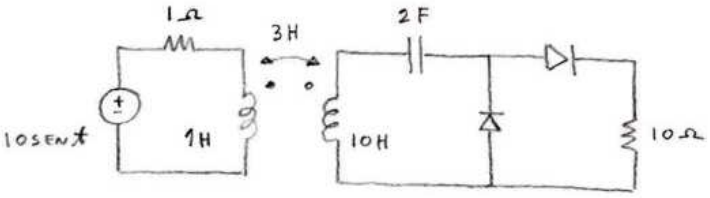
FAÇA $1+\frac{R_2}{R_1} = K$

O QUE FAZ ESSE CIRCUITO?

(3) ESCREVA UM SISTEMA DE MALHAS QUE CALCULE A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO DO CIRCUITO EM $t = t_0 + \Delta t$, USANDO O MÉTODO "BACKWARD" DE EULER E O MÉTODO DE NEWTON-RAPHSON.

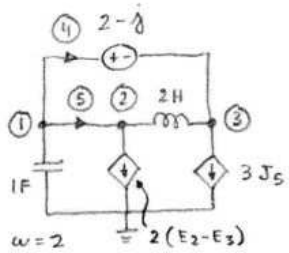
OS DIODOS SÃO MODELADOS COMO:





CIRCUITOS ELÉTRICOS II – 1º SEMESTRE DE 2007 – 1ª PROVA – GABARITO 34 ALUNOS

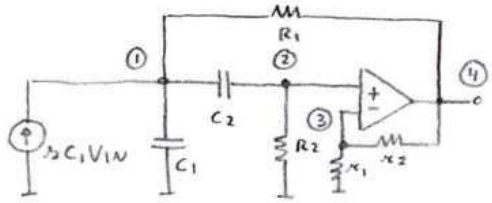
①



$$\begin{bmatrix} j2 & 0 & 0 & +1 & +1 \\ 0 & \frac{1}{j4}+2 & -\frac{1}{j4}-2 & 0 & -1 \\ 0 & -\frac{1}{j4} & \frac{1}{j4} & -1 & +3 \\ +1 & 0 & -1 & 0 & 0 \\ +1 & -1 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ J_4 \\ J_5 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 2-j \\ 0 \end{bmatrix}$$

O AMPLIFICADOR FOI TRATADO COMO ADMITÂNCIA

②



$$\begin{bmatrix} sC_1+sC_2+\frac{1}{R_1} & -sC_2 & 0 & -\frac{1}{R_1} \\ -sC_2 & sC_2+\frac{1}{R_2} & 0 & 0 \\ 0 & 0 & \frac{1}{x_1}+\frac{1}{x_2} & -\frac{1}{x_2} \\ -\frac{1}{R_1} & 0 & -\frac{1}{x_2} & \frac{1}{R_1}+\frac{1}{x_2} \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ E_4 \end{bmatrix}$$

$$= \begin{bmatrix} sC_1V_{IN} \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

RESTA:

$$\begin{bmatrix} sC_1+sC_2+\frac{1}{R_1} & -sC_2 & -\frac{1}{R_1} \\ -sC_2 & sC_2+\frac{1}{R_2} & 0 \\ 0 & \frac{1}{x_1}+\frac{1}{x_2} & -\frac{1}{x_2} \end{bmatrix} \begin{bmatrix} E_1 \\ E_{2,3} \\ E_4 \end{bmatrix} = \begin{bmatrix} sC_1V_{IN} \\ 0 \\ 0 \end{bmatrix}$$

$K = 1 + \frac{x_2}{x_1}$

$\frac{x_2}{x_1} = K - 1$

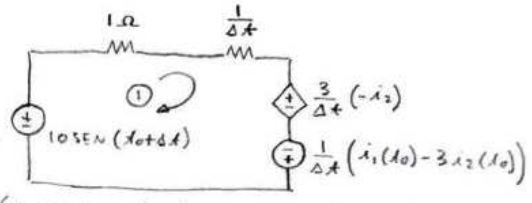
$1 - \frac{x_2}{x_1} = 1 - K + 1 = -K$

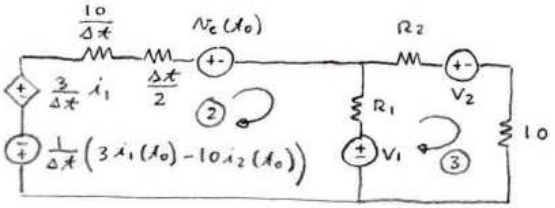
$$\frac{E_4}{V_{IN}} = \frac{-s^2C_1C_2\left(\frac{1}{x_1}+\frac{1}{x_2}\right)}{\left(s^2C_1C_2+\frac{sC_1}{R_2}+\frac{sC_2}{R_2}+\cancel{\frac{sC_2}{R_1}}+\frac{1}{R_1R_2}\right)\left(-\frac{1}{x_2}\right)+sC_2\left(\frac{1}{x_1}+\cancel{\frac{1}{x_2}}\right)} = \frac{\left(1+\frac{x_2}{x_1}\right)s^2}{s^2+s\left(\frac{1}{C_2R_2}+\frac{1}{C_1R_2}-\frac{x_2}{x_1}\frac{1}{R_1C_1}\right)+\frac{1}{R_1R_2C_1C_2}}$$

$$= \frac{Ks^2}{s^2+s\left(\frac{1}{C_2R_2}+\frac{1}{C_1R_2}-\frac{K-1}{C_1R_1}\right)+\frac{1}{R_1R_2C_1C_2}}$$

É UM PASSA-ALTAS DE 2ª ORDEM (OU FICINO)

③





$$R_1 = \begin{cases} 1 \text{ SE } i_{3M} - i_{2M} \geq 0 \\ 10^6 \text{ SE NÃO} \end{cases} \qquad R_2 = \begin{cases} 1 \text{ SE } i_{3M} \geq 0 \\ 10^6 \text{ SE NÃO} \end{cases}$$

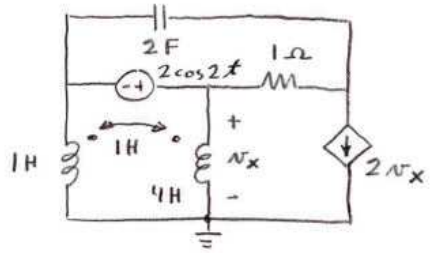
$V_1 = V_2 = 0$!

$v_c(t_0) = v_c(t_0 - \Delta t) + \frac{\Delta t}{2} i_2(t_0)$ ou $v_c(0)$

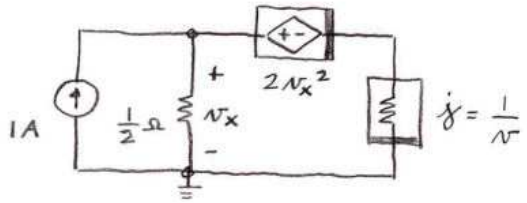
$$\begin{bmatrix} 1+\frac{1}{\Delta t} & -\frac{3}{\Delta t} & 0 \\ -\frac{3}{\Delta t} & \frac{10}{\Delta t}+\frac{\Delta t}{2}+R_1 & -R_1 \\ 0 & -R_1 & R_1+R_2+10 \end{bmatrix} \begin{bmatrix} i_{1_{M+1}}(t_0+\Delta t) \\ i_{2_{M+1}}(t_0+\Delta t) \\ i_{3_{M+1}}(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} 10\,SEN(t_0+\Delta t)+\frac{1}{\Delta t}\left(i_1(t_0)-3i_2(t_0)\right) \\ -\frac{1}{\Delta t}\left(3i_1(t_0)-10i_2(t_0)-v_c(t_0)\right) \\ 0 \end{bmatrix}$$

CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2007 - 1ª PROVA

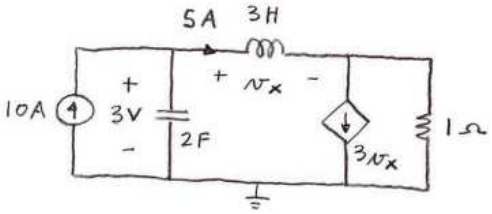
(1) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL COM TAMANHO MÍNIMO E O SISTEMA NODAL MODIFICADO, PARA ANÁLISE NO ESTADO PERMANENTE SENOIDAL.



(2) PARA O CIRCUITO NÃO LINEAR ABAIXO, ESCREVA AS EQUAÇÕES NODAIS MODIFICADAS NÃO LINEARES, E O SISTEMA QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON.

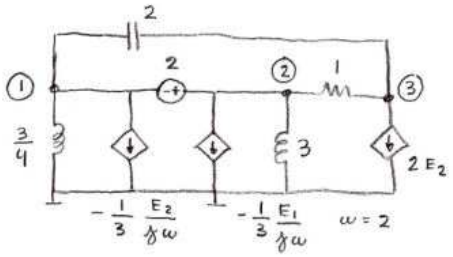


(3) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL QUE CALCULA A SOLUÇÃO 0.1 SEGUNDOS ALÉM DO TEMPO EM QUE O CIRCUITO É MOSTRADO, USANDO O MÉTODO "BACKWARD" DE EULER.



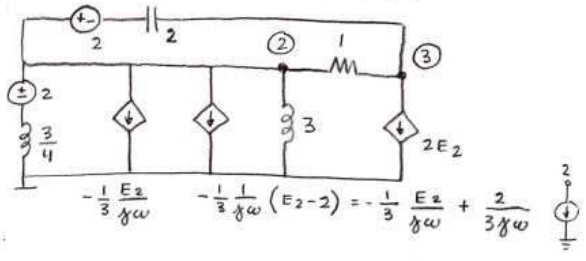
CIRCUITOS ELÉTRICOS II – 2º SEMESTRE DE 2007 – 1ª PROVA – GABARITO 23 ALUNOS

①



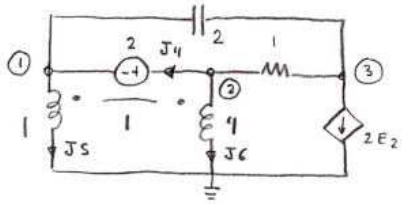
$$[L] = \begin{bmatrix} 1 & 1 \\ 1 & 4 \end{bmatrix} \Rightarrow [\Gamma] = \frac{1}{3}\begin{bmatrix} 4 & -1 \\ -1 & 1 \end{bmatrix}$$

DESLOCANDO A FONTE PARA A ESQUERDA



$$\begin{bmatrix} \frac{4}{3j2} + 2j2 - \frac{2}{3j2} + \frac{1}{3j2} + 1 & -1-2j2 \\ -1-2j2+2 & 1+2j2 \end{bmatrix}\begin{bmatrix} E_2 \\ E_3 \end{bmatrix} =$$

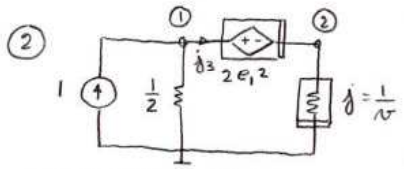
$$= \begin{bmatrix} \frac{2}{\frac{3}{4}j2} + 2j2.2 - \frac{2}{3j2} \\ -2j2.2 \end{bmatrix}$$



	1	2	3	4	5	6	
1	j2.2	0	-j2.2	-1	+1	0	E_1
2	0	1	-1	+1	0	+1	E_2
3	-j2.2	-1+2	1+j2.2	0	0	0	E_3
4	+1	-1	0	0	0	0	J_{V4}
5	-1	0	0	0	j2	j2	J_{V5}
6	0	-1	0	0	j2	j2.4	J_{V6}

$$= \begin{bmatrix} 6 \\ 0 \\ 0 \\ -2 \\ 0 \\ 0 \end{bmatrix}$$

②



MNA NÃO LINEAR

① $2e_1 + jV3 = 1$

② $-jV3 + \frac{1}{e_2} = 0$

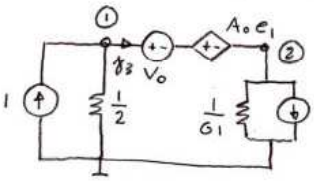
③ $e_1 - e_2 - 2e_1^2 = 0$

SISTEMA MNA PARA N.R.:

	1	2	3	
1	2	0	+1	e_{1m+1}
2	0	G_1	-1	e_{2m+1}
3	$-1+A_0$	+1	0	jV_{3m+1}

$$= \begin{bmatrix} 1 \\ -I_1 \\ -V_0 \end{bmatrix}$$

$e_1 - e_2 = V_0 + A_0 e_1$



MODELO P/ N R

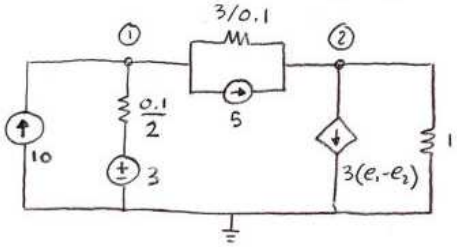
$G_1 = -\frac{1}{e_{2m}^2}$

$I_1 = \frac{1}{e_{2m}} - G_1 e_{2m} = \frac{2}{e_{2m}}$

$A_0 = 4e_{1m}$

$V_0 = 2e_{1m}^2 - A_0 e_{1m} = -2e_{1m}^2$

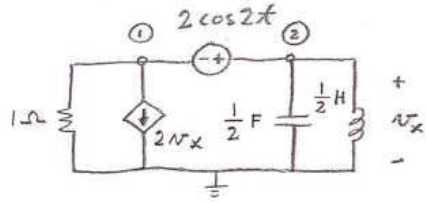
③



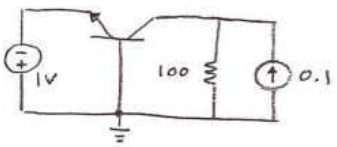
$$\begin{bmatrix} \frac{2}{0.1} + \frac{0.1}{3} & -\frac{0.1}{3} \\ -\frac{0.1}{3} + 3 & \frac{0.1}{3} + 1 - 3 \end{bmatrix}\begin{bmatrix} e_1(\chi_0+0.1) \\ e_2(\chi_0+0.1) \end{bmatrix} = \begin{bmatrix} \frac{2}{0.1}\cdot 3 - 5 \\ +10 \\ 5 \end{bmatrix}$$

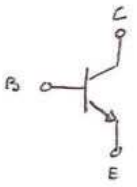
CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2008 - 1ª PROVA - 8/10/2008

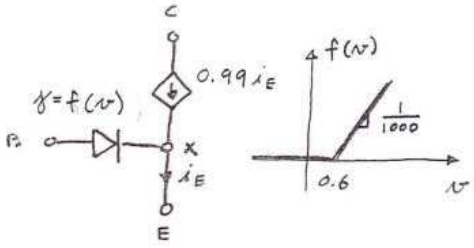
(1) CALCULE $e_1(t)$ E $e_2(t)$ NO ESTADO PERMANENTE, USANDO UMA ANÁLISE NODAL TRANSFORME O CIRCUITO CASO NECESSÁRIO



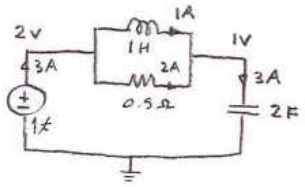
(2) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON. O TRANSISTOR É MODELADO COMO MOSTRADO.





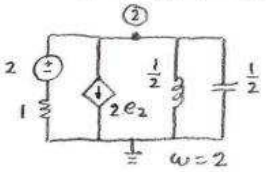


(3) PARA O CIRCUITO ABAIXO, DESENHE O MODELO E ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A SOLUÇÃO EM $t = 2.01$, DADO O ESTADO DO CIRCUITO EM $t = 2$, USANDO O MÉTODO DOS TRAPÉZIOS.



CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2008 - 1ª PROVA - GABARITO 19 ALUNOS

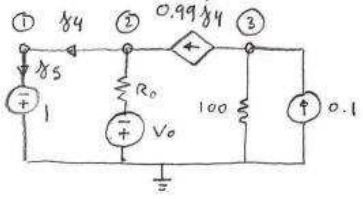
① DESLOCANDO A FONTE DE TENSÃO SÓ RESTA UM NÓ



$$\left[1+2+\frac{1}{j2\frac{1}{2}}+j2\frac{1}{2}\right]E_2=\left[2\right] \quad \therefore \quad 3E_2=2, \quad E_2=\frac{2}{3}$$

$$E_1=E_2-2=\frac{2}{3}-2=-\frac{4}{3} \qquad e_1(t)=-\frac{4}{3}\cos 2t \qquad e_2(t)=\frac{2}{3}\cos 2t$$

②



USANDO 5 INCÓGNITAS (PODIA FAZER $j_5=j_4$)

$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array}\begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \left[\begin{array}{ccccc} 0 & 0 & 0 & -1 & +1 \\ 0 & \frac{1}{R_0}* & 0 & +0.01 & 0 \\ 0 & 0 & \frac{1}{100} & +0.99 & 0 \\ -1 & +1 & 0 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 \end{array}\right] \end{array}\begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ j_4 \\ j_5 \end{bmatrix}=\begin{bmatrix} 0 \\ -V_0/R_0* \\ 0.1 \\ 0 \\ +1 \end{bmatrix}$$

(M+1)

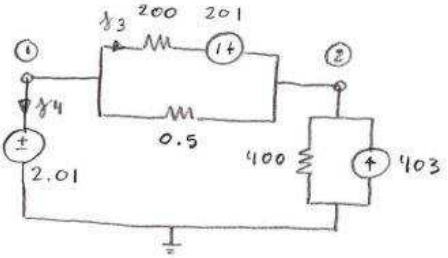
$V_0=0.6$

$R_0=1000$

NO CASO, A SOLUÇÃO É ACHADA IMEDIATAMENTE, POIS O PRÓXIMO SISTEMA SERÁ O MESMO

* COLOCAR ESTES TERMOS SE $-e_{2M}<0.6V$, SENÃO COLOCAR 0

③



INDUTOR NO MÉTODO DOS TRAPÉZIOS:

$$j(t_0+\Delta t)\approx j(t_0)+\frac{\Delta t}{2L}\left(v(t_0)+v(t_0+\Delta t)\right)$$

$$v(t_0+\Delta t)\approx \frac{2L}{\Delta t}\left(j(t_0+\Delta t)-j(t_0)\right)-v(t_0)$$

CAPACITOR:

$$j(t_0+\Delta t)\approx \frac{2C}{\Delta t}\left(v(t_0+\Delta t)-v(t_0)\right)-j(t_0)$$

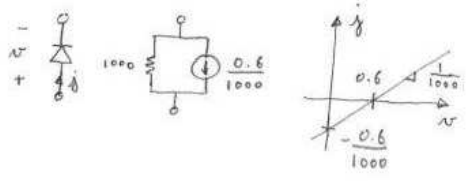
$$\frac{2L}{\Delta t}=\frac{2}{0.01}=200 \qquad \frac{\Delta t}{2C}=\frac{0.01}{4}=0.0025 \qquad \frac{2C}{\Delta t}=\frac{4}{0.01}=400$$

$$\frac{2L}{\Delta t}j_L(t_0)+v_L(t_0)=200\times 1+1=201$$

$$\frac{2C}{\Delta t}v_C(t_0)+j_C(t_0)=400\times 1+3=403$$

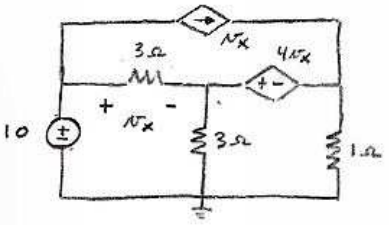
SISTEMA:

$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array}\begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \left[\begin{array}{cccc} 2 & -2 & +1 & +1 \\ -2 & 2+400 & -1 & 0 \\ -1 & +1 & 200 & 0 \\ -1 & 0 & 0 & 0 \end{array}\right] \end{array}\begin{bmatrix} e_1(2.01) \\ e_2(2.01) \\ j_3(2.01) \\ j_4(2.01) \end{bmatrix}=\begin{bmatrix} 0 \\ 403 \\ 201 \\ -2.01 \end{bmatrix}$$

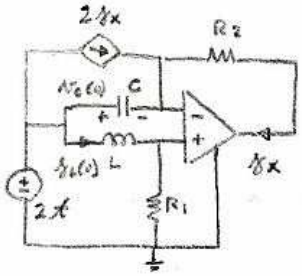


CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2009 - 1ª PROVA 8/5/2009

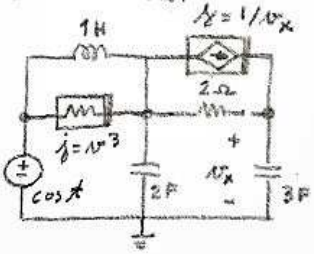
(1) ENCONTRE A SOLUÇÃO DO CIRCUITO USANDO UMA ANÁLISE NODAL, APÓS TRANSFORMAR O CIRCUITO ONDE NECESSÁRIO



(2) ESCREVA O SISTEMA NODAL MODIFICADO EM TRANSFORMADA DE LAPLACE, COM CONDIÇÕES INICIAIS

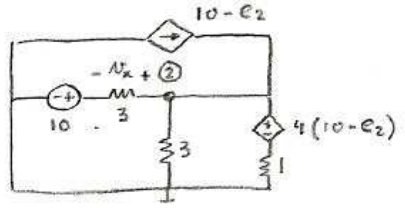


(3) ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO DO CIRCUITO EM $t = 1.1$, CONHECIDA A SOLUÇÃO EM $t=1$, $\vec{e}(1)$, E A ÚLTIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON, $\vec{e}_N(1.1)$. USE O MÉTODO "BACKWARD" DE EULER.



CIRCUITOS ELÉTRICOS II – 1º SEMESTRE DE 2009 – 1ª PROVA – GABARITO

(1) DESLIGANDO AS FONTES DE TENSÃO:



$V_x = 10 - e_2$

FAZENDO EQV. NORTON:

$$\left[\frac{1}{3} + \frac{1}{3} + 1\right] e_2 = \left[\frac{10}{3} + 10 - e_2 + 4(10 - e_2)\right]$$

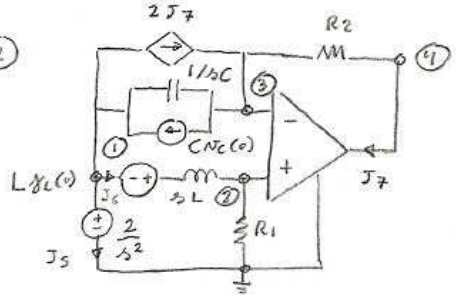
$$\left[\frac{2}{3} + 1 + 1 + 4\right] e_2 = \left[\frac{10}{3} + 10 + 40\right]$$

$$20\, e_2 = 160$$

$e_2 = 8\ V \quad e_1 = 10\ V \quad e_3 = e_2 - 40 + 4e_2$

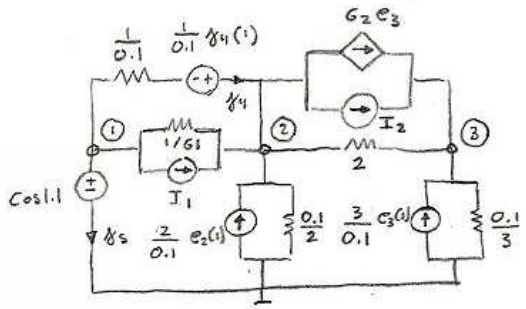
$= 8 - 40 + 32 = 0\ V$

(2)



$$\begin{bmatrix} sC & -sC & +1 & +1 & +2 \\ & \frac{1}{R_1} & & -1 & \\ -sC & sC+\frac{1}{R_2} & -\frac{1}{R_2} & & -2 \\ & -\frac{1}{R_2} & \frac{1}{R_2} & & +1 \\ -1 & & & & \\ -1 & 1 & & sL & \\ & -1 & +1 & & \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ E_4 \\ J_5 \\ J_6 \\ J_7 \end{bmatrix} = \begin{bmatrix} CV_C(0) \\ \\ -CV_C(0) \\ \\ -2/s^2 \\ L y_L(0) \\ \end{bmatrix}$$

(3)



$$G_1 = 3\left(e_{1m}(1.1) - e_{2m}(1.1)\right)^2$$

$$I_1 = \left(e_{1m}(1.1) - e_{2m}(1.1)\right)^3 - G_1\left(e_{1m}(1.1) - e_{2m}(1.1)\right)$$

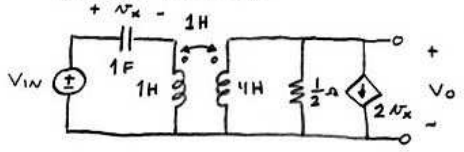
$$G_2 = -\frac{1}{e_{2m}(1.1)^2}$$

$$I_2 = \frac{1}{e_{3m}(1.1)} - G_2\, e_{3m}(1.1)$$

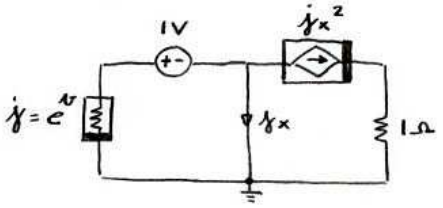
$$\begin{bmatrix} G_1 & -G_1 & & +1 & +1 \\ -G_1 & G_1+\frac{1}{2}+\frac{2}{0.1} & -\frac{1}{2}+G_2 & -1 & \\ & -\frac{1}{2} & \frac{1}{2}+\frac{3}{0.1}-G_2 & & \\ -1 & +1 & & \frac{1}{0.1} & \\ -1 & & & & \end{bmatrix} \begin{bmatrix} e_{1m+1}(1.1) \\ e_{2m+1}(1.1) \\ e_{3m+1}(1.1) \\ y_{4m+1}(1.1) \\ y_{5m+1}(1.1) \end{bmatrix} = \begin{bmatrix} -I_1 \\ +I_1 + \frac{2}{0.1} e_2(1) - I_2 \\ +I_2 + \frac{3}{0.1} e_3(1) \\ \frac{1}{0.1} y_4(1) \\ -\cos 1.1 \end{bmatrix}$$

CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2009 - 1ª PROVA

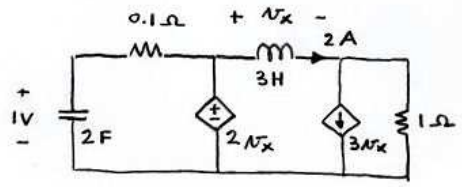
(1) PARA O CIRCUITO ABAIXO, OBTENHA $\frac{V_o}{V_{IN}}(j\omega)$ USANDO UMA ANÁLISE NODAL SIMPLES.



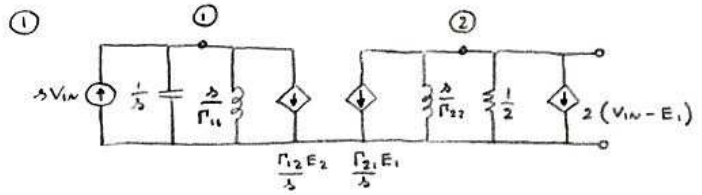
(2) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON. QUAL A SOLUÇÃO EXATA DESTE CIRCUITO?



(3) ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$ PARA O CIRCUITO ABAIXO, USANDO O MÉTODO "BACKWARD" DE EULER.



CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2009 - 1ª PROVA 23/10/2009 13 ALUNOS



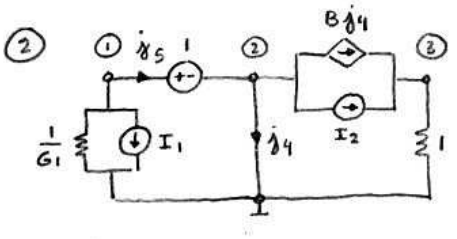
$$[L] = \begin{bmatrix} 1 & 1 \\ 1 & 4 \end{bmatrix} \quad [\Gamma] = \frac{1}{4-1}\begin{bmatrix} 4 & -1 \\ -1 & 1 \end{bmatrix}$$

$$[\Gamma] = \begin{bmatrix} \frac{4}{3} & -\frac{1}{3} \\ -\frac{1}{3} & \frac{1}{3} \end{bmatrix}$$

$$\begin{bmatrix} s + \frac{4}{3s} & -\frac{1}{3s} \\ -\frac{1}{3s} - 2 & 2 + \frac{1}{3s} \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} s\,V_{IN} \\ -2V_{IN} \end{bmatrix}$$

$$\frac{E_2}{V_{IN}} = \frac{-2s - \frac{8}{3s} + \frac{1}{3} + 2s}{2s + \frac{1}{3} + \frac{8}{3s} + \frac{4}{9s^2} - \frac{1}{9s^2} - \frac{2}{3s}} = \frac{\frac{1}{3} - \frac{8}{3s}}{2s + \frac{1}{3} + \frac{2}{s} + \frac{1}{3s^2}} \xrightarrow{\times 3s^2} \frac{s^2 - 8s}{6s^3 + s^2 + 6s + 1}$$

$$\frac{V_o}{V_{IN}}(j\omega) = \frac{-\omega^2 - 8j\omega}{-6j\omega^3 - \omega^2 + 6j\omega + 1}$$



$$G_1 = e^{e_{1m}}$$

$$I_1 = e^{e_{1m}} - G_1 e_{1m}$$

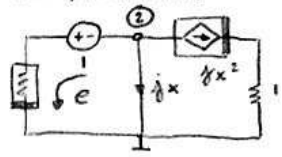
$$B = 2y_{4m}$$

$$I_2 = y_{4m}^2 - B\,y_{4m}$$

$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \left[\begin{array}{ccccc} G_1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1+B & -1 \\ 0 & 0 & 1 & -B & 0 \\ 0 & -1 & 0 & 0 & 0 \\ -1 & +1 & 0 & 0 & 0 \end{array}\right] \end{array} \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ y_4 \\ y_5 \end{bmatrix} = \begin{bmatrix} -I_1 \\ -I_2 \\ I_2 \\ 0 \\ -1 \end{bmatrix}$$

m+1

SOLUÇÃO EXATA:



$$e + yx + yx^2 = 0 \quad \therefore \quad yx = \frac{-1 \pm \sqrt{1-4e}}{2}$$

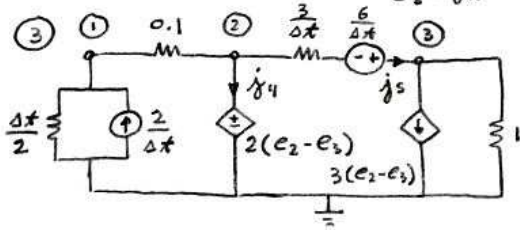
É COMPLEXO O CIRCUITO NÃO TEM SOLUÇÃO REAL

$e_1 = 1$

$e_2 = 0$

$e_3 = yx^2$

ASSIM SÓ HAVERIA SOLUÇÃO SE A CORRENTE NA FONTE DE TENSÃO FOSSE MENOR QUE 1/4 A, OU SE A FONTE DE CORRENTE ESTIVESSE INVERTIDA



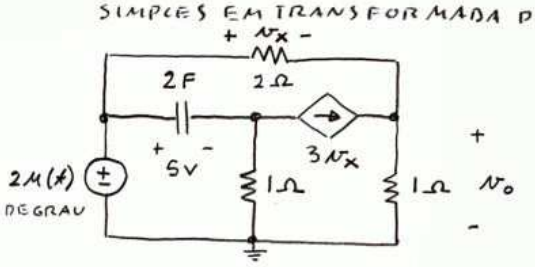
$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \left[\begin{array}{ccccc} \frac{2}{\Delta t}+10 & -10 & 0 & 0 & 0 \\ -10 & 10 & 0 & 1 & 1 \\ 0 & 3 & 1-3 & 0 & -1 \\ 0 & 2-1 & -2 & 0 & 0 \\ 0 & -1 & 1 & 0 & \frac{3}{\Delta t} \end{array}\right] \end{array} \begin{bmatrix} e_1(t_0+\Delta t) \\ e_2(t_0+\Delta t) \\ e_3(t_0+\Delta t) \\ y_4(t_0+\Delta t) \\ y_5(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} 2/\Delta t \\ 0 \\ 0 \\ 0 \\ \frac{6}{\Delta t} \end{bmatrix}$$

$$e_2 = 2(e_2 - e_3)$$

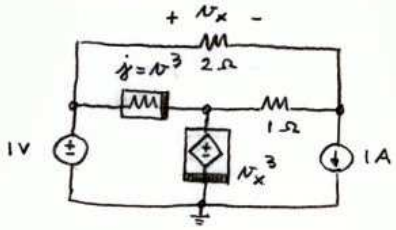
$$e_2 - e_3 = \frac{3}{\Delta t} y_5 - \frac{6}{\Delta t}$$

CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2010 - 1ª PROVA

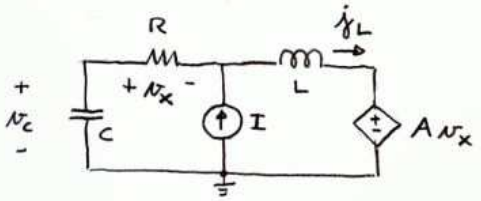
(1) PARA O CIRCUITO ABAIXO, ACHE $v_o(t)$ USANDO UMA ANÁLISE NODAL SIMPLES EM TRANSFORMADA DE LAPLACE



(2) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON



(3) ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$ USANDO O MÉTODO DE GEAR DE 2ª ORDEM, CONHECIDAS AS SOLUÇÕES EM $t = t_0$ E $t = t_0 - \Delta t$ PARA v_C E i_L



$$y(t_0+\Delta t) = y(t_0) + \int_{t_0}^{t_0+\Delta t} x(t)\,dt$$

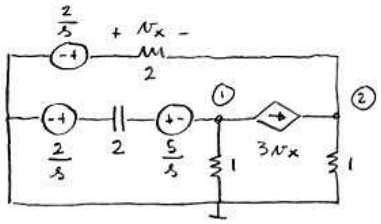
MÉTODO DE GEAR DE 2ª ORDEM:

$$y(t_0+\Delta t) \approx \frac{4}{3}y(t_0) - \frac{1}{3}y(t_0-\Delta t) + \frac{2}{3}\Delta t\, x(t_0+\Delta t)$$

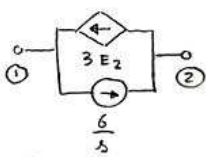
EXERCÍCIOS: HTTP://WWW.COE.UFRJ.BR/~ACMQ/CURSOS - PROVAS ANTIGAS

CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2010 - 1ª PROVA - GABARITO

(1)



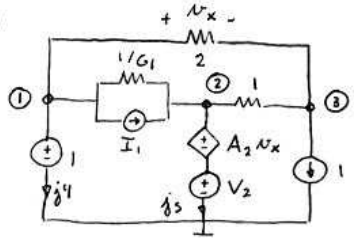
$V_x = \frac{2}{s} - E_2$



$$\begin{bmatrix} 2s+1 & -3 \\ 0 & 3+\frac{3}{2} \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} -6-\frac{6}{s} \\ \frac{1}{s}+\frac{6}{s} \end{bmatrix} \begin{matrix} +3E_2 \\ -3E_2 \end{matrix}$$

$$V_o = E_2 = \frac{(2s+1)\frac{7}{s}}{(2s+1)\left(\frac{9}{2}\right)} = \frac{14}{9s} \qquad v_o = \frac{14}{9}$$

(2)



$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \left[\begin{array}{ccccc} G_1+0.5 & -G_1 & -0.5 & 1 & 0 \\ -G_1 & G_1+1 & -1 & 0 & 1 \\ -0.5 & -1 & 1.5 & 0 & 0 \\ -1 & 0 & 0 & 0 & 0 \\ A_2 & -1 & -A_2 & 0 & 0 \end{array}\right] \end{array} \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ j\omega_4 \\ j\omega_5 \end{bmatrix} = \begin{bmatrix} -I_1 \\ +I_1 \\ -1 \\ -1 \\ -V_2 \end{bmatrix}$$

$e_2 = A_2(e_1 - e_3) + V_2$

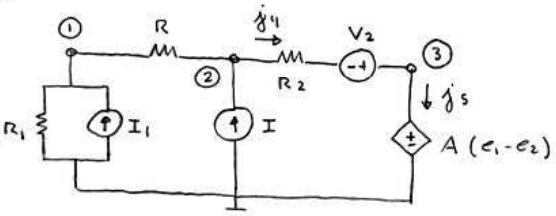
$G_1 = 3(e_{1M} - e_{2M})^2$

$I_1 = (e_{1M} - e_{2M})^3 - G_1(e_{1M} - e_{2M})$

$A_2 = 3(e_{1M} - e_{3M})^2$

$V_2 = (e_{1M} - e_{3M})^3 - A_2(e_{1M} - e_{3M})$

(3)



$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \left[\begin{array}{ccccc} \frac{1}{R_1}+\frac{1}{R} & -\frac{1}{R} & 0 & 0 & 0 \\ -\frac{1}{R} & \frac{1}{R} & 0 & +1 & 0 \\ 0 & 0 & 0 & -1 & +1 \\ 0 & -1 & +1 & R_2 & 0 \\ A & -A & -1 & 0 & 0 \end{array}\right] \end{array} \begin{bmatrix} e_1 \\ e_2 \\ e_3 \\ j\omega_4 \\ j\omega_5 \end{bmatrix}_{M+1} = \begin{bmatrix} I_1 \\ I \\ 0 \\ V_2 \\ 0 \end{bmatrix}$$

CAPACITOR

$$v(t_0+\Delta t) = \frac{4}{3}v(t_0) - \frac{1}{3}v(t_0-\Delta t) + \frac{2}{3}\frac{\Delta t}{C}j(t_0+\Delta t) \quad \therefore \quad j(t_0+\Delta t) = \frac{3C}{2\Delta t}v(t_0+\Delta t) - \frac{2C}{\Delta t}v(t_0) + \frac{C}{2\Delta t}v(t_0-\Delta t)$$

$$R_1 = \frac{2}{3}\frac{\Delta t}{C} \qquad I_1 = \frac{2C}{\Delta t}v(t_0) - \frac{C}{2\Delta t}v(t_0-\Delta t), \quad v = e_1$$

INDUTOR

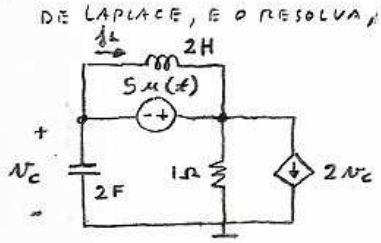
$$j(t_0+\Delta t) = \frac{4}{3}j(t_0) - \frac{1}{3}j(t_0-\Delta t) + \frac{2}{3}\frac{\Delta t}{L}v(t_0+\Delta t)$$

$$v(t_0+\Delta t) = \frac{3L}{2\Delta t}j(t_0+\Delta t) - \frac{2L}{\Delta t}j(t_0) + \frac{L}{2\Delta t}j(t_0-\Delta t)$$

$$R_2 = \frac{3L}{2\Delta t} \qquad v_2 = \frac{2L}{\Delta t}j(t_0) - \frac{L}{2\Delta t}j(t_0-\Delta t), \quad j = j\omega_4$$

CIRCUITOS ELÉTRICOS I - 2º SEMESTRE DE 2010 - 1ª PROVA

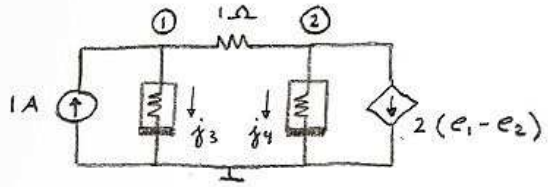
(1) PARA O CIRCUITO ABAIXO, ESCREVA UM SISTEMA NODAL MODIFICADO EM TRANSFORMADA DE LAPLACE, E O RESOLVA, ACHANDO A SOLUÇÃO NO TEMPO



$v_c(0) = 1V$

$i_L(0) = 0$

(2) NO CIRCUITO NÃO LINEAR ABAIXO, A ÚLTIMA SOLUÇÃO ENCONTRADA PELO MÉTODO DE NEWTON-RAPHSON FOI:



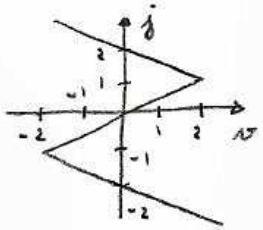
$e_1 = 1V$

$e_2 = -2V$

$i_3 = \frac{1}{2} A$

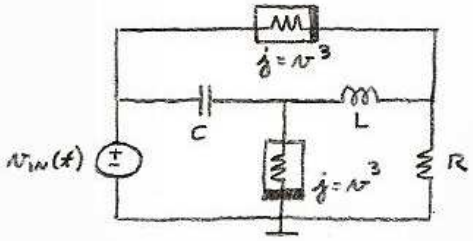
$i_4 = 3A$

OS RESISTORES NÃO LINEARES SÃO ASSIM:

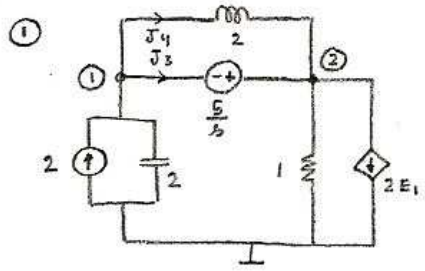


ESCREVA O SISTEMA QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO. POR QUE TEM QUE SER NODAL MODIFICADO?

(3) PARA O CIRCUITO ABAIXO, ESCREVA UM SISTEMA NODAL SIMPLES QUE CALCULE A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO EM $x = x_0 + \Delta x$ PELO MÉTODO DE NEWTON-RAPHSON, USANDO O MÉTODO "BACKWARD" DE EULER



CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2010 - 1ª PROVA - GABARITO 33 ALUNOS

① 

$$\begin{bmatrix} 2s & 0 & 1 & 1 \\ 2 & 1 & -1 & -1 \\ 1 & -1 & 0 & 0 \\ -1 & 1 & 0 & 2s \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ J_3 \\ J_4 \end{bmatrix} = \begin{bmatrix} 2 \\ 0 \\ -5/s \\ 0 \end{bmatrix}$$

SOMANDO AS DUAS PRIMEIRAS EQUAÇÕES : $(2s+2)E_1 + E_2 = 2$ E TEM-SE, DA TERCEIRA

$E_1 - E_2 = -\frac{5}{s}$ $\therefore E_2 = E_1 + \frac{5}{s} \Rightarrow (2s+2)E_1 + E_1 + \frac{5}{s} = 2$ $\therefore E_1 = \frac{2 - \frac{5}{s}}{2s+3} = \frac{s - \frac{5}{2}}{s\left(s+\frac{3}{2}\right)}$

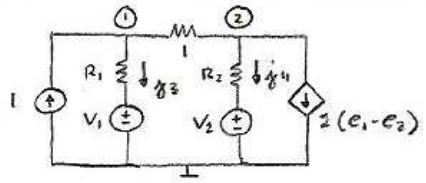
$$E_1 = \frac{-\frac{5}{2}/\frac{3}{2}}{s} + \frac{\frac{-\frac{3}{2} - \frac{5}{2}}{-3/2}}{s+\frac{3}{2}} = \frac{-\frac{5}{3}}{s} + \frac{\frac{8}{3}}{s+\frac{3}{2}} \Rightarrow e_1(t) = -\frac{5}{3} + \frac{8}{3}e^{-\frac{3}{2}t} \quad (e_1(0) = 1, \text{OK})$$

$e_2(t) = e_1(t) + 5 = \frac{10}{3} + \frac{8}{3}e^{-\frac{3}{2}t}$

$J_4 = -\frac{5}{2s^2}$ $\therefore j_4(t) = -\frac{5}{2}t$ DA 2ª EQUAÇÃO: $j_3(t) = 2e_1(t) + e_2(t) - j_4(t)$

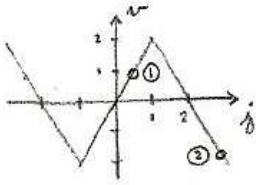
$j_3(t) = -\frac{10}{3} + \frac{16}{3}e^{-\frac{3}{2}t} + \frac{10}{3} + \frac{8}{3}e^{-\frac{3}{2}t} + \frac{5}{2}t = 8e^{-\frac{3}{2}t} + \frac{5}{2}t \quad (j_3(0) = 8\text{A}, \text{OK})$

② TEM QUE SER MNA DEVIDO AOS RESISTORES CONTROLADOS A CORRENTE



$$\begin{bmatrix} 1 & -1 & 1 & 0 \\ -1+2 & 1-2 & 0 & 1 \\ -1 & 0 & R_1 & 0 \\ 0 & -1 & 0 & R_2 \end{bmatrix} \begin{bmatrix} e_{1m+1} \\ e_{2m+1} \\ j_{3m+1} \\ j_{4m+1} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ -V_1 \\ -V_2 \end{bmatrix}$$

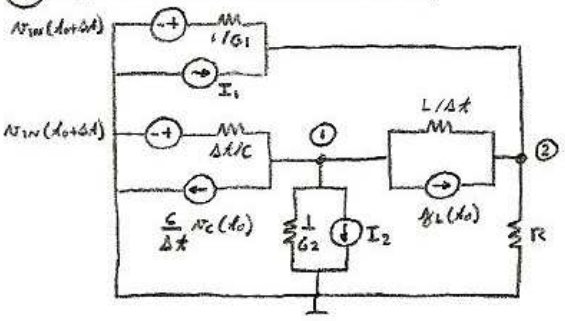
OBSERVANDO OS PONTOS DE OPERAÇÃO DOS RESISTORES



$R_1 = 2$, $V_1 = 0$

$R_2 = -2$, $V_2 = 4$

③ DESLOCANDO A FONTE DE TENSÃO:



$$\begin{bmatrix} \frac{C}{\Delta t} + \frac{\Delta t}{L} + G_2 & -\frac{\Delta t}{L} \\ -\frac{\Delta t}{L} & \frac{1}{R} + \frac{\Delta t}{L} + G_1 \end{bmatrix} \begin{bmatrix} e_{1_{m+1}}(t_0+\Delta t) \\ e_{2_{m+1}}(t_0+\Delta t) \end{bmatrix} =$$

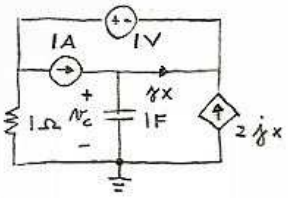
$$= \begin{bmatrix} \frac{C}{\Delta t} v_{1N}(t_0+\Delta t) - \frac{C}{\Delta t} v_C(t_0) - I_2 - j_L(t_0) \\ G_1 v_{1N}(t_0+\Delta t) + I_1 + j_L(t_0) \end{bmatrix}$$

$G_1 = 3\left(v_{1N}(t_0+\Delta t) - e_{2m}\right)^2$ $I_1 = \left(v_{1N}(t_0+\Delta t) - e_{2m}\right)^3 - G_1\left(v_{1N}(t_0+\Delta t) - e_{2m}\right)$

$v_C(t_0) = v_{1N}(t_0) - e_1(t_0)$

CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2011 - 1ª PROVA

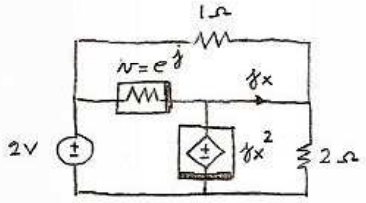
(1) ACHE $v_c(t)$ USANDO UM SISTEMA NODAL SIMPLES EM TRANSFORMADA DE LAPLACE.



$v_c(0) = 0\ V$

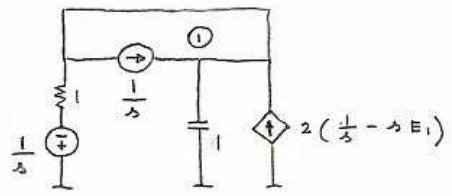
(2) PARA O MESMO CIRCUITO, ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$, CONHECIDA A SOLUÇÃO EM $t = t_0$, USANDO O MÉTODO DOS TRAPÉZIOS.

(3) PARA O CIRCUITO ABAIXO ESCREVA O SISTEMA DAS MALHAS, SIMPLES, QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON



CIRCUITOS ELÉTRICOS II – 1º SEMESTRE DE 2011 – 1ª PROVA – GABARITO 29 ALUNOS

(1)



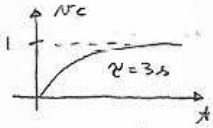
$$\left[s+1\right]E_1(s) = \left[-\frac{1}{s} + \frac{2}{s} - 2s\,E_1(s)\right]$$

$$\left[3s+1\right]E_1(s) = \frac{1}{s}$$

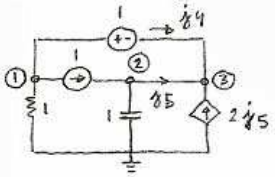
$$E_1(s) = \frac{1}{s(3s+1)} = \frac{\frac{1}{3}}{s^2+\frac{1}{3}s} = \frac{A}{s} + \frac{B}{s+\frac{1}{3}}$$

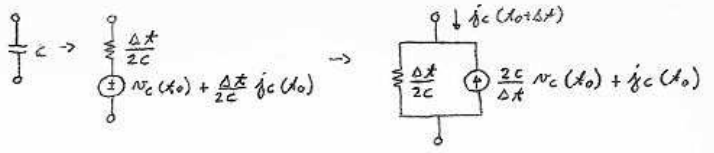
$$A = \left.\frac{\frac{1}{3}}{s+\frac{1}{3}}\right|_{s=0} = 1 \qquad B = \left.\frac{\frac{1}{3}}{s}\right|_{s=-\frac{1}{3}} = -1$$

$$E_1(s) = \frac{1}{s} - \frac{1}{s+\frac{1}{3}} \quad \therefore e_1(t) = 1 - e^{-\frac{1}{3}t}$$



(2)



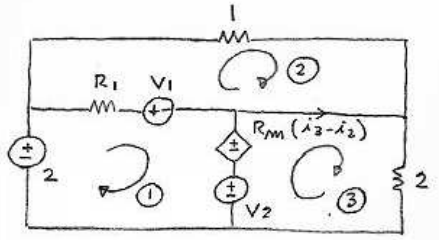


$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array}\begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \left[\begin{array}{ccc:cc} 1 & 0 & 0 & 1 & 0 \\ 0 & \frac{2}{\Delta t} & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 & -1-2 \\ \hdashline -1 & 0 & +1 & 0 & 0 \\ 0 & -1 & +1 & 0 & 0 \end{array}\right] \end{array}\begin{bmatrix} e_1(t_0+\Delta t) \\ e_2(t_0+\Delta t) \\ e_3(t_0+\Delta t) \\ jy4(t_0+\Delta t) \\ jy5(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} -1 \\ +1+\frac{2}{\Delta t}e_2(t_0) + j_c(t_0) \\ 0 \\ \hdashline -1 \\ 0 \end{bmatrix}$$

$j_c(t_0+\Delta t)$ DEVE SER CALCULADA COMO

$$j_c(t_0+\Delta t) = e_2(t_0+\Delta t)\frac{2}{\Delta t} - \frac{2}{\Delta t}e_2(t_0) - j_c(t_0)$$

(3)



$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array}\begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} R_1 & -R_1-R_m & 0+R_m \\ -R_1 & R_1+1 & 0 \\ 0 & 0+R_m & 2-R_m \end{bmatrix} \end{array}\begin{bmatrix} i_{1m+1} \\ i_{2m+1} \\ i_{3m+1} \end{bmatrix} = \begin{bmatrix} 2-V_1-V_2 \\ V_1 \\ V_2 \end{bmatrix}$$

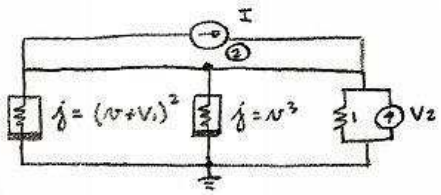
$$R_1 = e^{(i_{1m}-i_{2m})}$$

$$V_1 = e^{(i_{1m}-i_{2m})} - R_1(i_{1m}-i_{2m})$$

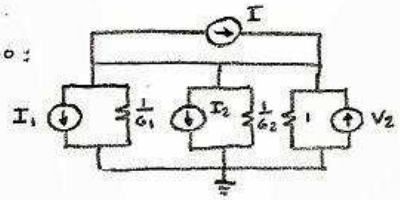
$$R_m = 2(i_{3m}-i_{2m})$$

$$V_2 = (i_{3m}-i_{2m})^2 - R_m(i_{3m}-i_{2m})$$

DESLOCANDO AS FONTES ANTES DA LINEARIZAÇÃO:



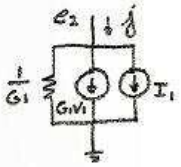
LINEARIZANDO:



$G_1' = 2(e_{2_M} + V_1)$ $\qquad G_2 = 3e_{2M}^2$

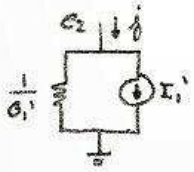
$I_1' = (e_{2_M} + V_1)^2 - G_1' e_{2M}$ $\qquad I_2 = e_{2M}^3 - G_2 e_{2M}$

NA VERSÃO ANTERIOR, A FONTE DESLOCADA PARA O RESISTOR $j = v^2$ GERAVA:



$$j = G_1 e_2 + G_1 V_1 + I_1$$
$$= 2e_{1M} e_2 + 2e_{1M} V_1 + e_{1M}^2 - 2e_{1M}^2$$
$$= 2e_{1M} e_2 + 2e_{1M} V_1 - e_{1M}^2$$

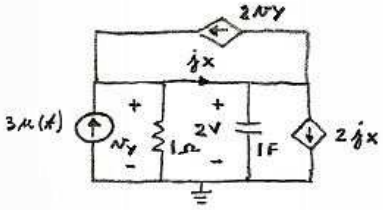
NA NOVA VERSÃO:



$$j = G_1' e_2 + I_1'$$
$$= 2(e_{2M} + V_1) e_2 + (e_{2M} + V_1)^2 - 2(e_{2M} + V_1) e_{2M}$$
$$= 2e_{1M} e_2 + e_{1M}^2 - 2e_{1M} e_{2M}$$
$$= 2e_{1M} e_2 + e_{1M}^2 - 2e_{1M}(e_{1M} - V_1)$$
$$= 2e_{1M} e_2 - e_{1M}^2 + 2e_{1M} V_1$$ O MESMO, COMO TINHA QUE SER.

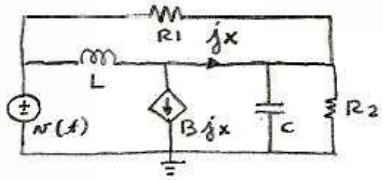
CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2011 - 1ª PROVA

(1) ACHE $V_c(t)$ USANDO UM SISTEMA NODAL MODIFICADO EM TRANSFORMADA DE LAPLACE

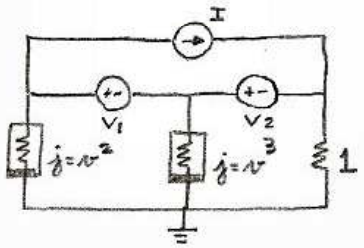


$-\frac{3}{s+3}$

(2) PARA O CIRCUITO ABAIXO ESCREVA O SISTEMA NODAL QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$, USANDO MODELOS PARA FONTES DE TENSÃO E CURTOS COM AMP. OPS. IDEAIS E O MÉTODO BACKWARD DE EULER, DE FORMA A NÃO AUMENTAR O NÚMERO DE EQUAÇÕES ALÉM DO NÚMERO DE NÓS

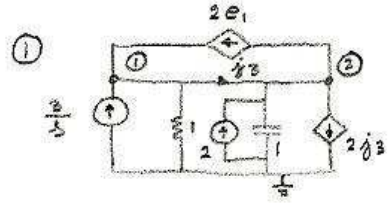


(3) PARA O CIRCUITO, ESCREVA O SISTEMA QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON. USE UM SISTEMA NODAL SIMPLES.



CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2011 - 1ª PROVA - GABARITO 19/10/2011

30 ALUNOS



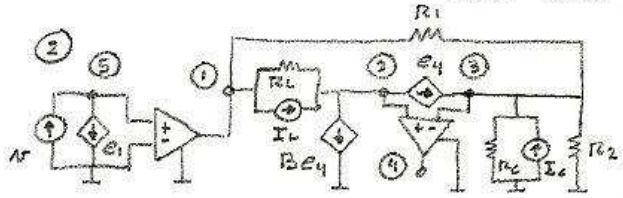
$$\begin{bmatrix} 1-2 & 0 & +1 \\ 2 & s & -1+2 \\ -1 & +1 & 0 \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ J_3 \end{bmatrix} = \begin{bmatrix} \frac{3}{s} \\ 2 \\ 0 \end{bmatrix}$$

COMO $E_1 = E_2$:

$$\begin{bmatrix} -1 & 1 \\ 2+s & 1 \end{bmatrix} \begin{bmatrix} E_{1,2} \\ J_3 \end{bmatrix} = \begin{bmatrix} \frac{3}{s} \\ 2 \end{bmatrix}$$

$$E_{1,2} = \frac{\frac{3}{s} - 2}{-1-2-s} = \frac{2-\frac{3}{s}}{s+3} = \frac{2}{s+3} - \frac{3}{s(s+3)} = \frac{2}{s+3} + \frac{-1}{s} + \frac{+1}{s+3}$$

$$v_c(t) = e_{1,2}(t) = 2e^{-3t} - 1 + e^{-3t} = 3e^{-3t} - 1$$



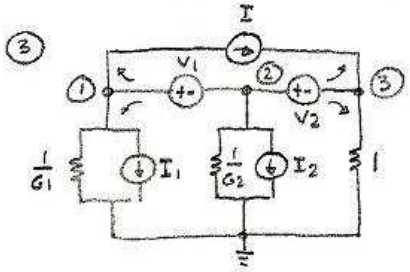
$$R_L = \frac{L}{\Delta t} \quad I_L = j_L(t_0)$$

$$R_C = \frac{\Delta t}{C} \quad I_C = \frac{C}{\Delta t} v_C(t_0)$$

$$\begin{bmatrix} \frac{1}{R_1}+\frac{1}{R_L} & -\frac{1}{R_L} & -\frac{1}{R_1} & 0 & 0 \\ -\frac{1}{R_L} & \frac{1}{R_L} & 0 & 1+B & 0 \\ -\frac{1}{R_1} & 0 & \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_C} & -1 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} e_1(t_0+\Delta t) \\ e_2(t_0+\Delta t) \\ e_3(t_0+\Delta t) \\ e_4(t_0+\Delta t) \\ e_5(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} -I_L \\ +I_L \\ +I_C \\ 0 \\ v(t_0+\Delta t) \end{bmatrix}$$

REITA:

$$\begin{bmatrix} -\frac{1}{R_L} & \frac{1}{R_L} & 1+B \\ -\frac{1}{R_1} & \frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_C} & -1 \\ 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} e_1(t_0+\Delta t) \\ e_{2,3}(t_0+\Delta t) \\ e_4(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} +I_L \\ +I_C \\ v(t_0+\Delta t) \end{bmatrix}$$



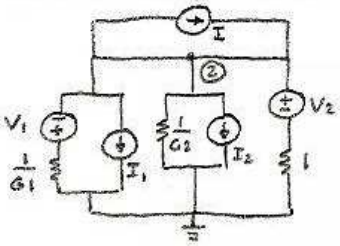
$$G_1 = 2e_{1M}$$

$$I_1 = e_{1M}^2 - G_1 e_{1M}$$

$$G_2 = 3e_{2M}^2$$

$$I_2 = e_{2M}^3 - G_2 e_{2M}$$

DESLOCANDO AS FONTES DE TENSÃO:



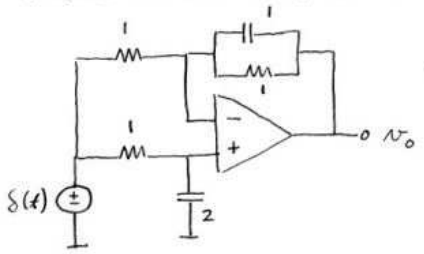
$$\left[G_1 + G_2 + 1\right] e_{2_{M+1}} = \left[-G_1 V_1 - I_1 - I_2 + V_2\right]$$

$$e_{1M+1} = e_{2M+1} + V_1$$

$$e_{3M+1} = e_{2M+1} + V_2$$

CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2012 - PRIMEIRA PROVA

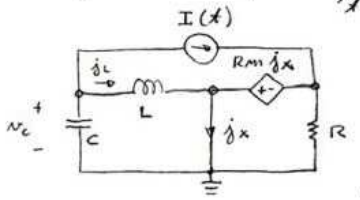
(1) RESOLVA O CIRCUITO ABAIXO, ACHANDO $v_o(t)$, USANDO UMA ANÁLISE NODAL COM NÃO MAIS QUE DUAS EQUAÇÕES, EM TRANSFORMADA DE LAPLACE.



C.I. NULAS

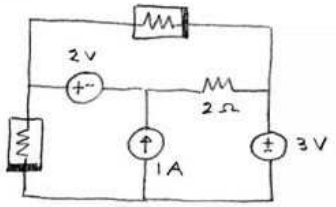
(2) ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$ PARA O CIRCUITO, USANDO O MÉTODO DE GEAR GENÉRICO:

$$y(t_0+\Delta t) = y(t_0) + \int_{t_0}^{t_0+\Delta t} x(t)\,dt \;\rightarrow\; y(t_0+\Delta t) \approx a_0 y(t_0) + a_1 y(t_0-\Delta t) + \cdots + b\,\Delta t\, x(t_0+\Delta t)$$

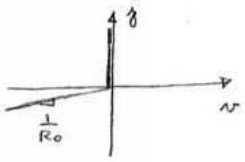


SÃO CONHECIDAS AS SOLUÇÕES ANTERIORES E DADOS OS COEFICIENTES $a_0 \cdots b$

(3) PARA O CIRCUITO ABAIXO ESCREVA O SISTEMA DE MALHAS QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON



OS RESISTORES NÃO LINEARES SÃO DIODOS:

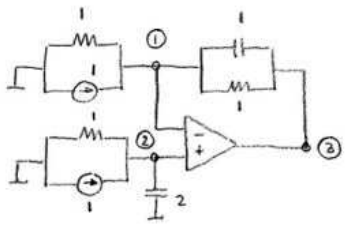


SE $j > 0$, $v = 0$

SE $j \leq 0$, $v = R_0 j$

CIRCUITOS ELÉTRICOS II – 1º SEMESTRE DE 2012 – PRIMEIRA PROVA – GABARITO (17 ALUNOS)

①



$$\begin{bmatrix} s+2 & 0 & -s-1 \\ 0 & 2s+1 & 0 \\ -s-1 & 0 & s+1 \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \\ E_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} s+2 & -s-1 \\ 2s+1 & 0 \end{bmatrix} \begin{bmatrix} E_{12} \\ E_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$E_3 = \frac{s+2-2s-1}{2s^2+2s+s+1} = \frac{-s+1}{2s^2+3s+1} = \frac{-\frac{1}{2}(s-1)}{s^2+\frac{3}{2}s+\frac{1}{2}}$$

$$= \frac{-\frac{1}{2}(s-1)}{(s+1)(s+\frac{1}{2})} = \frac{-\frac{1}{2}\frac{(-1-1)}{-1+0.5}}{s+1} + \frac{-\frac{1}{2}\frac{-0.5-1}{-0.5+1}}{s+\frac{1}{2}} = \frac{-2}{s+1} + \frac{1.5}{s+0.5}$$

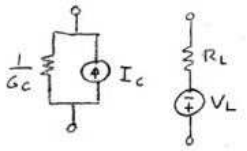
$$v_o(t) = -2e^{-t} + 1.5e^{-0.5t}$$

②

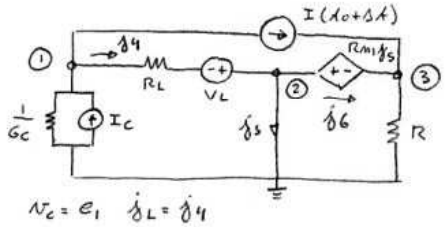
CAPACITOR: $v(t_0+\Delta t) = a_0 v(t_0) + a_1 v(t_0-\Delta t) + \cdots + b\frac{\Delta t}{C} j(t_0+\Delta t)$

$$j(t_0+\Delta t) = \frac{C}{b\Delta t}\left(v(t_0+\Delta t) - a_0 v(t_0) - a_1 v(t_0-\Delta t) - \cdots\right)$$

INDUTOR: $v(t_0+\Delta t) = \frac{L}{b\Delta t}\left(j(t_0+\Delta t) - a_0 j(t_0) - a_1 j(t_0-\Delta t) - \cdots\right)$



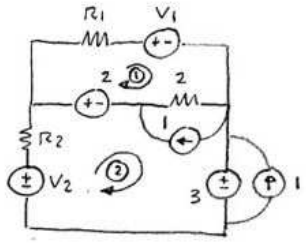
$$G_C = \frac{C}{b\Delta t};\quad I_C = \frac{C}{b\Delta t}\left(a_0 v(t_0) + a_1 v(t_0-\Delta t) + \cdots\right);\quad R_L = \frac{L}{b\Delta t};\quad V_L = \frac{L}{b\Delta t}\left(a_0 j(t_0) + a_1 j(t_0-\Delta t) + \cdots\right)$$



$v_C = e_1 \quad j_L = j_4$

$$\begin{bmatrix} G_C & 0 & 0 & +1 & 0 & 0 \\ 0 & 0 & 0 & -1 & +1 & +1 \\ 0 & 0 & \frac{1}{R} & 0 & 0 & -1 \\ -1 & +1 & 0 & R_L & 0 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & -1 & +1 & 0 & +R_m & 0 \end{bmatrix} \begin{bmatrix} e_1(t_0+\Delta t) \\ e_2(t_0+\Delta t) \\ e_3(t_0+\Delta t) \\ j_4(t_0+\Delta t) \\ j_5(t_0+\Delta t) \\ j_6(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} I_C - I(t_0+\Delta t) \\ 0 \\ +I(t_0+\Delta t) \\ +V_L \\ 0 \\ 0 \end{bmatrix}$$

③



$$\begin{bmatrix} R_1+2 & -2 \\ -2 & R_2+2 \end{bmatrix} \begin{bmatrix} i_{1m+1} \\ i_{2m+1} \end{bmatrix} = \begin{bmatrix} 2+2-V_1 \\ -2-2-3+V_2 \end{bmatrix}$$

DIODOS:

SE $i_{1m} > 0$: $R_1 = 0,\ V_1 = 0$

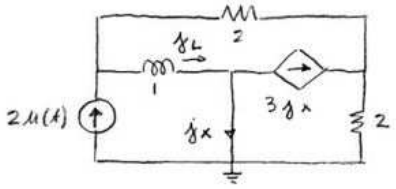
SE $i_{1m} \leq 0$: $R_1 = R_0,\ V_1 = 0$

SE $i_{2m} > 0$: $R_2 = R_0,\ V_2 = 0$

SE $i_{2m} \leq 0$: $R_2 = 0,\ V_2 = 0$

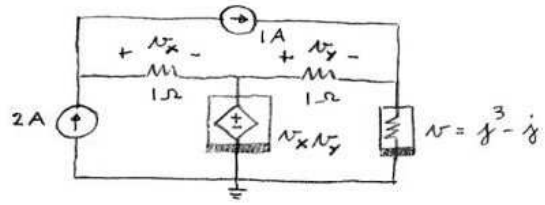
CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2012 - 1ª PROVA

(1) PARA O CIRCUITO ABAIXO, CALCULE $i_L(t)$ USANDO UM SISTEMA NODAL SIMPLES EM TRANSFORMADA DE LAPLACE

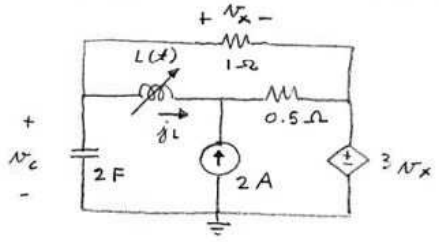


$i_L(0) = 1A$

(2) PARA O CIRCUITO ABAIXO ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON



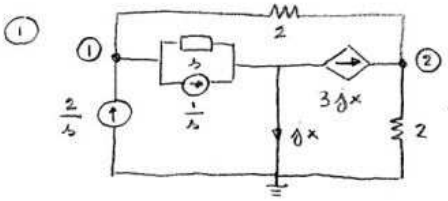
(3) ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$ USANDO O MÉTODO BACKWARD DE EULER, CONHECIDA A SOLUÇÃO EM $t = t_0$



$L(t) = 2 \operatorname{sen} t + 2$

CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2012 - 1ª PROVA - GABARITO 37 ALUNOS

①



MAIS SIMPLES SOMAR CORRENTES NO NÓ DE TERRA PARA ACHAR j_x

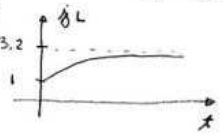
$J_x = \frac{2}{s} - \frac{E_2}{2} \quad \therefore \; 3J_x = \frac{6}{s} - \frac{3}{2}E_2$

$$\begin{bmatrix} \frac{1}{2}+\frac{1}{s} & -\frac{1}{2} \\ -\frac{1}{2} & \frac{1}{2}+\frac{1}{2}+\frac{3}{2}=\frac{5}{2} \end{bmatrix} \begin{bmatrix} E_1 \\ E_2 \end{bmatrix} = \begin{bmatrix} \frac{1}{s} \\ \frac{6}{s} - \frac{3}{2}E_2 \end{bmatrix}$$

$$E_1 = \frac{\frac{1}{s}\frac{5}{2} + \frac{6}{s}\frac{1}{2}}{\frac{1}{2}\frac{5}{2} + \frac{1}{s}\frac{5}{2} - \frac{1}{4}} = \frac{\frac{1}{s}\frac{11}{2}}{1 + \frac{1}{s}\frac{5}{2}} = \frac{\frac{11}{2}}{s+\frac{5}{2}}$$

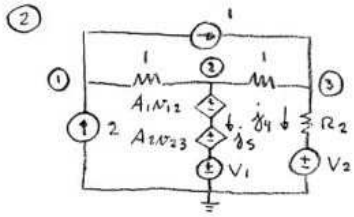
$$J_L = \frac{E_1}{s} + \frac{1}{s} = \frac{\frac{11}{2}}{s\left(s+\frac{5}{2}\right)} + \frac{1}{s} = \frac{\frac{11}{2}\frac{2}{5}}{s} - \frac{\frac{11}{2}\frac{2}{5}}{s+\frac{5}{2}} + \frac{1}{s}$$

$$J_L = \frac{\frac{11}{5}+1}{s} - \frac{\frac{11}{5}}{s+\frac{5}{2}} \quad \therefore \; j_L(t) = \frac{16}{5} - \frac{11}{5}e^{-\frac{5}{2}t}$$



$$J_L(s) = \frac{s+8}{s^2+\frac{5}{2}s}$$

②



$A_1 = e_{2M} - e_{3M}$

$A_2 = e_{1M1} - e_{2M1}$

$V_1 = (e_{1M1}-e_{2M1})(e_{2M}-e_{3M}) - (e_{2M}-e_{3M})(e_{1M1}-e_{2M1}) - (e_{1M1}-e_{2M1})(e_{2M}-e_{3M})$

$= -(e_{1M1}-e_{2M1})(e_{2M}-e_{3M})$

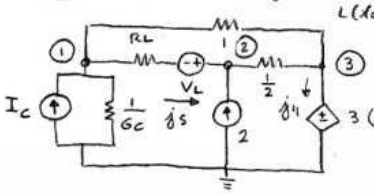
$R_2 = 3j_{4M1}^2 - 1 \qquad V_2 = j_{4M1}^3 - j_{4M} - (3j_{4M1}^2 - 1)j_{4M} = -2j_{4M1}^3$

$$\begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{bmatrix} 1 & -1 & 0 & 0 & 0 \\ -1 & 2 & -1 & 0 & 1 \\ 0 & -1 & 1 & 1 & 0 \\ 0 & 0 & -1 & R_2 & 0 \\ A_1 & -A_1+A_2 & -A_2 & 0 & 0 \end{bmatrix} \begin{bmatrix} e_{1M+1} \\ e_{2M+1} \\ e_{3M+1} \\ j_{4M+1} \\ j_{5M+1} \end{bmatrix} = \begin{bmatrix} 1 \\ 0 \\ 1 \\ -V_2 \\ -V_1 \end{bmatrix}$$

$e_3 = R_2 j_4 + V_2$

$e_2 = A_1(e_1 - e_2) + A_2(e_2 - e_3) + V_1$

③ $j_L(t_0+\Delta t) \approx j_L(t_0)\frac{L(t_0)}{L(t_0+\Delta t)} + \frac{\Delta t}{L(t_0+\Delta t)}v(t_0+\Delta t) \quad \therefore \; v(t_0+\Delta t) \approx \frac{L(t_0+\Delta t)}{\Delta t} j_L(t_0+\Delta t) - \frac{L(t_0)}{\Delta t} j_L(t_0)$



$R_L = \frac{L(t_0+\Delta t)}{\Delta t} = \frac{\text{SEN}(t_0+\Delta t)+2}{\Delta t} \qquad G_C = \frac{C}{\Delta t} = \frac{2}{\Delta t}$

$V_L = \frac{L(t_0)}{\Delta t} j_L(t_0) = \frac{\text{SEN}(t_0)+2}{\Delta t} j_L(t_0) \qquad I_C = \frac{C}{\Delta t} e_1(t_0) = \frac{2}{\Delta t} e_1(t_0)$

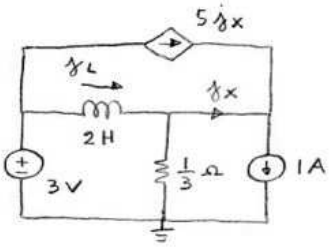
$$\begin{array}{c} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{bmatrix} G_C+1 & 0 & -1 & 0 & 1 \\ 0 & 1 & -2 & 0 & -1 \\ -1 & -2 & 3 & 1 & 0 \\ 3 & 0 & -4 & 0 & 0 \\ -1 & +1 & 0 & 0 & R_L \end{bmatrix} \begin{bmatrix} e_1(t_0+\Delta t) \\ e_2(t_0+\Delta t) \\ e_3(t_0+\Delta t) \\ j_4(t_0+\Delta t) \\ j_5(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} I_C \\ 2 \\ 0 \\ 0 \\ V_L \end{bmatrix}$$

$e_3 = 3(e_1 - e_3)$

$e_1 - e_2 = R_L j_5 - V_L$

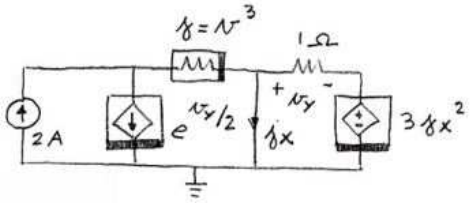
CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2013 - 1ª PROVA

(1) ACHE A SOLUÇÃO PARA $i_L(t)$ USANDO UMA ANÁLISE NODAL SIMPLES EM TRANSFORMADA DE LAPLACE

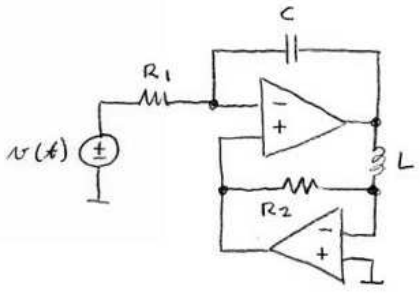


$i_L(0) = 1A$

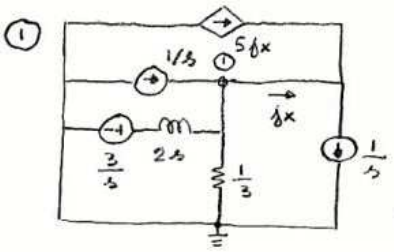
(2) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON



(3) ESCREVA O SISTEMA NODAL, ELIMINADO OS AMPLIFICADORES OPERACIONAIS, QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$ USANDO O MÉTODO BACKWARD DE EULER, CONHECIDA A SOLUÇÃO EM $t = t_0$



CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2013 - 1ª PROVA - GABARITO

① 

$$Jx + 5Jx = \frac{1}{s}$$

$$6Jx = \frac{1}{s} \quad \therefore \quad Jx = \frac{1}{6s}$$

$$5Jx = \frac{5}{6}\frac{1}{s} \quad \text{UMA FONTE CONSTANTE}$$

$$① \quad \left(3 + \frac{1}{2s}\right) E_1 = \frac{1}{s} - \frac{1}{s} + \frac{5}{6}\frac{1}{s} + \frac{3}{2s^2}$$

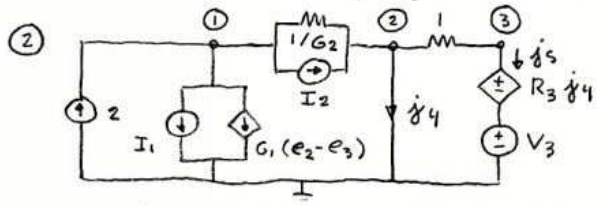
$$E_1 = \frac{\frac{5}{6}\frac{1}{s} + \frac{3}{2s^2}}{3 + \frac{1}{2s}} = \frac{\frac{5}{3} + \frac{3}{s}}{6s + 1} = \frac{\frac{5}{18} + \frac{1}{2s}}{s + 1/6} = \frac{\frac{5}{18}s + \frac{1}{2}}{s(s + 1/6)} = \frac{5}{18}\frac{s + 1.8}{s(s+1/6)} \quad \text{(OK)}$$

$$E_1 = \frac{A}{s} + \frac{B}{s+\frac{1}{6}} \qquad A = \frac{\frac{1}{2}}{\frac{1}{6}} = 3 \qquad B = \frac{\frac{5}{18}\left(-\frac{1}{6}\right) + \frac{1}{2}}{-\frac{1}{6}} = \frac{-\frac{5}{18} + 3}{-1} = \frac{5}{18} - 3 = -\frac{49}{18} = -2{,}722$$

$$e_1(t) = 3 - 2.722\, e^{-\frac{1}{6}t}$$

$$j_L(t) = 3e_1(t) + jx = 3e_1(t) + \frac{1}{6} = 9 - \frac{49}{6}e^{-\frac{1}{6}t} + \frac{1}{6} = \frac{55}{6} - \frac{49}{6}e^{-\frac{1}{6}t}$$

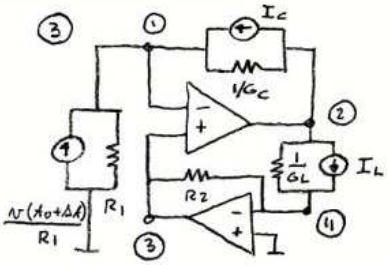
VERIFICANDO: $j_L(0) = \frac{55}{6} - \frac{49}{6} = 1$, OK $\qquad j_L(\infty) = \frac{55}{6} = 3\times 3 + \frac{1}{6}$, OK

② 

$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array}\begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} G_2 & -G_2+G_1 & -G_1 & 0 & 0 \\ -G_2 & G_2+1 & -1 & +1 & 0 \\ 0 & -1 & 1 & 0 & +1 \\ 0 & -1 & 0 & 0 & 0 \\ 0 & 0 & -1 & R_3 & 0 \end{bmatrix} \end{array} \begin{bmatrix} e_{1\,m+1} \\ e_{2\,m+1} \\ e_{3\,m+1} \\ j_{4\,m+1} \\ j_{s\,m+1} \end{bmatrix} = \begin{bmatrix} 2 - I_1 - I_2 \\ I_2 \\ 0 \\ 0 \\ -V_3 \end{bmatrix}$$

$$G_1 = \frac{1}{2}e^{(e_{2m}-e_{3m})/2} \qquad I_1 = e^{(e_{2m}-e_{3m})/2} - G_1(e_{2m}-e_{3m}) \qquad R_3 = 6\, j_{4m}$$

$$G_2 = 3(e_{1m}-e_{2m})^2 \qquad I_2 = (e_{1m}-e_{2m})^3 - G_2(e_{1m}-e_{2m}) \qquad V_3 = 3j_{4m}^2 - R_3 j_{4m}$$

③ 

$$G_C = \frac{C}{\Delta t} \qquad I_C = \frac{C}{\Delta t}\left(e_1(\lambda_0) - e_2(\lambda_0)\right)$$

$$G_L = \frac{\Delta t}{L} \qquad I_L = j_L(\lambda_0) \quad \text{(CALCULADO AO FIM DA ANÁLISE)}$$

SISTEMA SEM OS AMP. OPS.:

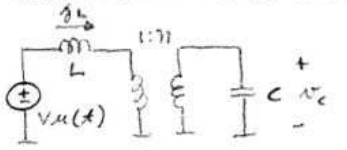
$$\begin{array}{c} \\ 1 \\ \leftarrow 2 \\ \leftarrow 3 \\ 4 \end{array}\begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{bmatrix} \frac{1}{R_1}+G_C & -G_C & 0 & 0 \\ -G_C & G_C+G_L & 0 & -G_L \\ 0 & 0 & \frac{1}{R_2} & -\frac{1}{R_2} \\ 0 & -G_L & -\frac{1}{R_2} & \frac{1}{R_2}+G_L \end{bmatrix} \end{array} \begin{bmatrix} e_1(\lambda_0+\Delta\lambda) \\ e_2(\lambda_0+\Delta\lambda) \\ e_3(\lambda_0+\Delta\lambda) \\ e_4(\lambda_0+\Delta\lambda) \end{bmatrix} = \begin{bmatrix} \frac{N(\lambda_0+\Delta\lambda)}{R_1} + I_C \\ -I_C - I_L \\ 0 \\ +I_L \end{bmatrix}$$

SISTEMA RESTANTE:

$$\begin{array}{c} \\ 1 \\ 2 \end{array}\begin{array}{c} \begin{array}{cc} 1 & 2 \end{array} \\ \begin{bmatrix} \frac{1}{R_1}+G_C & -G_C \\ -\frac{1}{R_2} & -G_L \end{bmatrix} \end{array} \begin{bmatrix} e_{1,3}(\lambda_0+\Delta\lambda) \\ e_2(\lambda_0+\Delta\lambda) \end{bmatrix} = \begin{bmatrix} \frac{N(\lambda_0+\Delta\lambda)}{R_1} + I_C \\ +I_L \end{bmatrix}$$

CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2013 - 1ª PROVA

(1) PARA O CIRCUITO, CALCULE $v_c(t)$ E $i_L(t)$ USANDO UMA ANÁLISE NODAL MODIFICADA EM TRANSFORMADA DE LAPLACE. PROCURE USAR APENAS DUAS EQUAÇÕES.



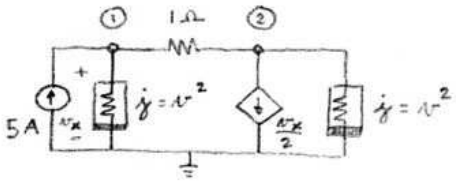
$v_c(0) = 0$

$i_L(0) = 0$

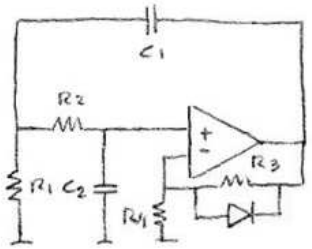
PLOTE AS RESPOSTAS

UM TRANSFORMADOR NÃO IDEAL MUDARIA O QUÊ? (NÃO REANALISE)

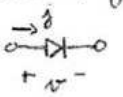
(2) PARA O CIRCUITO NÃO LINEAR ABAIXO, CALCULE A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO USANDO O MÉTODO DE NEWTON-RAPHSON E UMA ANÁLISE NODAL. A SOLUÇÃO ATUAL VALE $\vec{e}_{n1} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$



(3) ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO DO CIRCUITO EM $t = t_0 + \Delta t$, USANDO O MÉTODO DE NEWTON-RAPHSON E A INTEGRAÇÃO "BACKWARD" DE EULER.
A CORRENTE DE SAÍDA DO AMP. OP. DEVE SER CALCULADA.



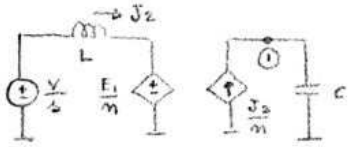
DIODO: $i = I_S\left(e^{v/V_T} - 1\right)$



O CIRCUITO É UM OSCILADOR SENOIDAL COM O DIODO USADO PARA LIMITAR A AMPLITUDE.

CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2013 - 1ª PROVA - GABARITO — 39 ALUNOS

①



BASTA UMA CORRENTE, JÁ QUE É A MESMA NOS 3 RAMOS DA ESQUERDA

A EQUAÇÃO CORRESPONDENTE É $\frac{E_1}{n} + sLJ_2 = \frac{V}{s}$

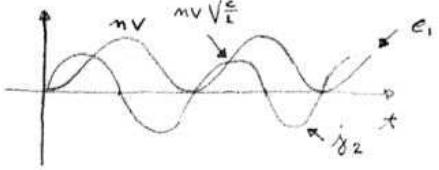
$$\begin{bmatrix} sC & -\frac{1}{n} \\ \frac{1}{n} & sL \end{bmatrix} \begin{bmatrix} E_1 \\ J_2 \end{bmatrix} = \begin{bmatrix} 0 \\ \frac{V}{s} \end{bmatrix}$$

$$E_1 = \frac{\frac{V}{ns}}{s^2LC + \frac{1}{n^2}} = \frac{\frac{V}{nLC}}{s\left(s^2 + \frac{1}{n^2LC}\right)} = \frac{nV}{s} - \frac{nVs}{s^2 + \frac{1}{n^2LC}}$$

$$e_1(t) = nV\left(1 - \cos\frac{1}{n\sqrt{LC}}t\right)$$

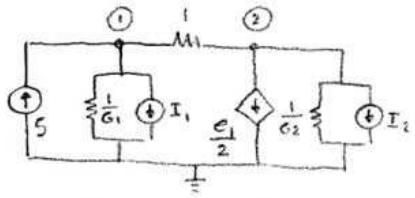
$$J_2 = \frac{CV}{s^2LC + \frac{1}{n^2}} = \frac{\frac{V}{L}}{s^2 + \frac{1}{n^2LC}} = \frac{nV\sqrt{\frac{C}{L}}\frac{1}{n\sqrt{LC}}}{s^2 + \frac{1}{n^2LC}}$$

$$j_2(t) = nV\sqrt{\frac{C}{L}}\,\text{sen}\,\frac{1}{n\sqrt{LC}}t$$



SE O TRANSFORMADOR FOR REAL SURGE UMA RAMPA SOMADA A j_2. e_1 CONTINUA COM NÍVEL CC, POIS j_2 AUMENTA CONTINUAMENTE

②



$G_1 = 2e_{1M} = 2$

$I_1 = e_{1M}^2 - G_1e_{1M} = 1 - 2 = -1$

$G_2 = 2e_{2M} = 2$

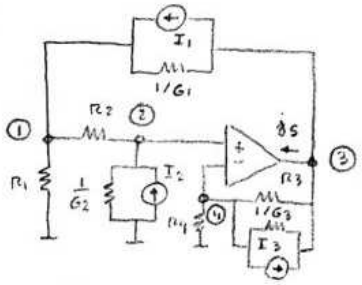
$I_2 = e_{2M}^2 - G_2e_{2M} = -1$

$$\begin{bmatrix} 3 & -1 \\ -1+0.5 & 3 \end{bmatrix} \begin{bmatrix} e_{1M+1} \\ e_{2M+1} \end{bmatrix} = \begin{bmatrix} 6 \\ 1 \end{bmatrix}$$

-0.5

$$e_{1M+1} = \frac{6\times3 + 1}{3\times3 - 0.5} = \frac{19}{8.5} = 2.24 \qquad e_{2M+1} = \frac{3\times1 + 0.5\times6}{3\times3 - 0.5\times1} = \frac{6}{8.5} = 0.701$$

③



$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{array} \begin{array}{c} \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \left[\begin{array}{ccccc|c} \frac{1}{R_1}+\frac{1}{R_2}+G_1 & -\frac{1}{R_2} & -G_1 & 0 & 0 \\ -\frac{1}{R_2} & \frac{1}{R_2}+G_2 & 0 & 0 & 0 \\ -G_1 & 0 & \frac{1}{R_3}+G_1+G_3 & -\frac{1}{R_3}-G_3 & +1 \\ 0 & 0 & -\frac{1}{R_3}-G_3 & \frac{1}{R_3}+\frac{1}{R_4}+G_3 & 0 \\ 0 & -1 & 0 & +1 & 0 \end{array}\right] \end{array} \begin{bmatrix} e_{1M+1}(t_0+\Delta t) \\ e_{2M+1}(t_0+\Delta t) \\ e_{3M+1}(t_0+\Delta t) \\ e_{1M+1}(t_0+\Delta t) \\ j_{5M+1}(t_0+\Delta t) \end{bmatrix} = \begin{bmatrix} I_1 \\ I_2 \\ -I_1+I_3 \\ -I_3 \\ 0 \end{bmatrix}$$

$$G_1 = \frac{\Delta t}{C_1} \qquad I_1 = \frac{C_1}{\Delta t}\left(e_1(t_0) - e_3(t_0)\right)$$

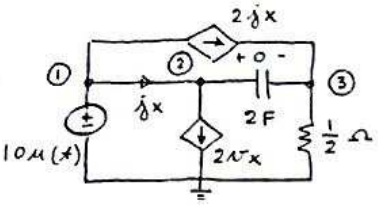
$$G_2 = \frac{\Delta t}{C_2} \qquad I_2 = \frac{C_2}{\Delta t}\,e_2(t_0)$$

$$G_3 = \frac{I_S}{V_T}\,e^{\left(e_{1M}(t_0+\Delta t) - e_{3M}(t_0+\Delta t)\right)/V_T}$$

$$I_3 = I_S\left(e^{\left(e_{1M}(t_0+\Delta t) - e_{3M}(t_0+\Delta t)\right)/V_T} - 1\right) - G_3\left(e_{1M}(t_0+\Delta t) - e_{3M}(t_0+\Delta t)\right)$$

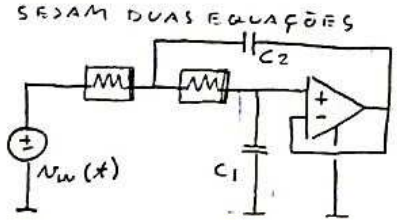
CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2011 - 1ª PROVA

(1) PARA O CIRCUITO ABAIXO, ENCONTRE AS TENSÕES NODAIS $\vec{e}(t)$ USANDO UMA ANÁLISE NODAL SIMPLES EM TRANSFORMADA DE LAPLACE.



(2) PARA O MESMO CIRCUITO, ESCREVA UM SISTEMA NODAL MODIFICADO NO ESTADO PERMANENTE SENOIDAL, COM A FONTE DE TENSÃO SENDO $10 \operatorname{sen} 2t$. ESTE SISTEMA CALCULA A SOLUÇÃO CORRETA? POR QUÊ?

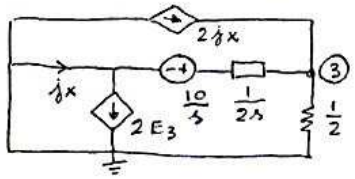
(3) PARA O CIRCUITO ABAIXO, ESCREVA UM SISTEMA NODAL QUE CALCULE A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO EM $t = t_0 + \Delta t$, USANDO A APROXIMAÇÃO "BACKWARD" DE EULER E O MÉTODO DE NEWTON-RAPHSON, DE FORMA QUE SEJAM DUAS EQUAÇÕES



RESISTORES: $j = kv^3$

CIRCUITOS ELÉTRICOS II - 1º SEMESTRE DE 2014 - 1ª PROVA - GABARITO — 51 ALUNOS

① DESLOCANDO A FONTE DE TENSÃO E O CORTE



$jx = 2E_3 + \left(\frac{10}{s} - E_3\right)2s = 2E_3 + 20 - 2sE_3$

RESTA UMA EQUAÇÃO

TAMBÉM PODE: $jx + 2jx = 4E_3$

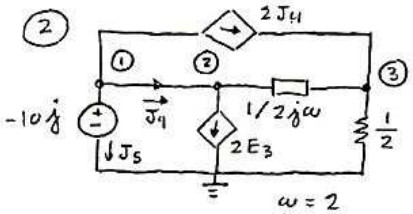
$(2s+2)E_3 = 20 + 4E_3 + 40 - 4sE_3$

$(6s-2)E_3 = 60$

$E_3(s) = \frac{10}{s - \frac{1}{3}} \quad \therefore e_3(t) = 10e^{+\frac{t}{3}}u(t)$

$e_1(t) = e_2(t) = 10u(t)$

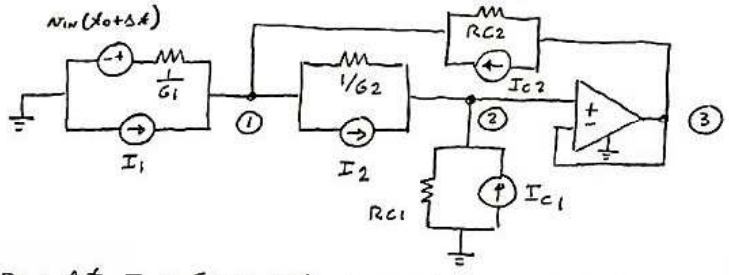
②



	1	2	3	4	5	
1	0	0	0	1+2	1	$\begin{bmatrix} E_1 \\ E_2 \\ E_3 \\ J_4 \\ J_5 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 10j \end{bmatrix}$
2	0	4j	-4j+2	-1	0	
3	0	-4j	4j+2	-2	0	
4	-1	+1	0	0	0	
5	-1	0	0	0	0	

A SOLUÇÃO NÃO INCLUI O TRANSIENTE INSTÁVEL QUE O CIRCUITO GERA

③ ESCREVENDO O SISTEMA SEM O AMP. OP., COM A FONTE DESLOCADA PARA O MODELO LINEARIZADO DO RESISTOR LIGADO A ELA:



$G_1 = 3k\left(N_{1N}(t_0+\Delta t) - e_{1m}(t_0+\Delta t)\right)^2$

$I_1 = k\left(N_{1N}(t_0+\Delta t) - e_{1m}(t_0+\Delta t)\right)^3 - G_1\left(N_{1N}(t_0+\Delta t) - e_{1m}(t_0+\Delta t)\right)$

$G_2 = 3k\left(e_{1m}(t_0+\Delta t) - e_{2m}(t_0+\Delta t)\right)^2$

$I_2 = k\left(e_{1m}(t_0+\Delta t) - e_{2m}(t_0+\Delta t)\right)^3 - G_2\left(e_{1m}(t_0+\Delta t) - e_{2m}(t_0+\Delta t)\right)$

$R_{C1} = \frac{\Delta t}{C_1} \quad I_{C1} = \frac{C_1}{\Delta t}e_2(t_0) \qquad R_{C2} = \frac{\Delta t}{C_2} \quad I_{C2} = \frac{C_2}{\Delta t}\left(e_1(t_0) - e_3(t_0)\right)$

	1	2	3	
1	$G_1+G_2+\frac{1}{R_{C2}}$	$-G_2$	$-\frac{1}{R_{C2}}$	$\begin{bmatrix} e_{1m+1}(t_0+\Delta t) \\ e_2'' \\ e_3'' \end{bmatrix} = \begin{bmatrix} G_1N_{1N}(t_0+\Delta t) + I_1 - I_2 + I_{C2} \\ I_2 + I_{C1} \\ -I_{C2} \end{bmatrix}$
2	$-G_2$	$G_2+\frac{1}{R_{C1}}$	0	
3	$-\frac{1}{R_{C2}}$	0	$\frac{1}{R_{C2}}$	

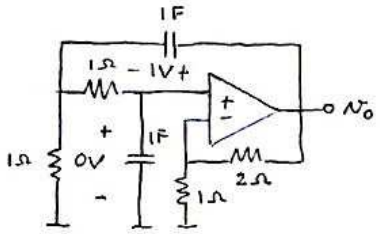
← 4 + 3

REDUZINDO O SISTEMA:

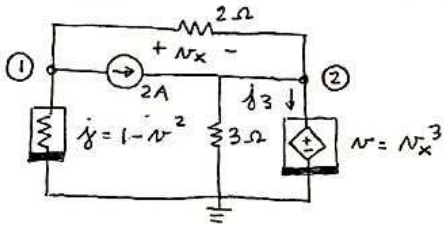
	1	2	
1	$G_1+G_2+\frac{1}{R_{C2}}$	$-G_2-\frac{1}{R_{C2}}$	$\begin{bmatrix} e_{1m+1}(t_0+\Delta t) \\ e_{2,3}'' \end{bmatrix} = \begin{bmatrix} G_1N_{1N}(t_0+\Delta t) + I_1 - I_2 + I_{C2} \\ I_2 + I_{C1} \end{bmatrix}$
2	$-G_2$	$G_2+\frac{1}{R_{C1}}$	

CIRCUITOS ELÉTRICOS II - 2º SEMESTRE DE 2014 - PRIMEIRA PROVA

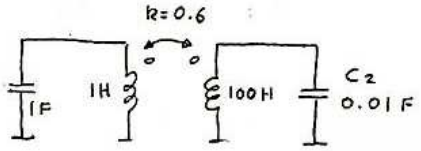
(1) USE UMA ANÁLISE NODAL COM ELIMINAÇÃO DO AMP. OP. EM TRANSFORMADA DE LAPLACE PARA ACHAR $v_o(t)$



(2) PARA O CIRCUITO ABAIXO, ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A PRÓXIMA APROXIMAÇÃO DA SOLUÇÃO PELO MÉTODO DE NEWTON-RAPHSON A ÚLTIMA SOLUÇÃO OBTIDA FOI $e_1 = 1V$, $e_2 = 2V$, $j_3 = 1A$



(3) ESCREVA O SISTEMA NODAL MODIFICADO QUE CALCULA A SOLUÇÃO EM $t = t_0 + \Delta t$ USANDO O MÉTODO "BACKWARD" DE EULER, DADA A SOLUÇÃO EM $t = t_0$

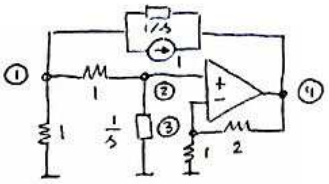


O QUE MUDA SE C_2 VARIAR NO TEMPO, $C_2(t) = C_0 + at$?

17 ALUNOS

CIRCUITOS ELÉTRICOS II – 2º SEMESTRE DE 2014 – PRIMEIRA PROVA – GABARITO

①



SISTEMA SEM O AMP-OP:

$$\begin{matrix} & 1 & 2 & 3 & 4 \\ 1 & s+2 & -1 & 0 & -s \\ 2 & -1 & s+1 & 0 & 0 \\ 3 & 0 & 0 & \frac{3}{2} & -\frac{1}{2} \\ \leftarrow 4 & -s & 0 & -\frac{1}{2} & s+\frac{1}{2} \end{matrix} \begin{bmatrix} E_1(s) \\ E_2(s) \\ E_3(s) \\ E_4(s) \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \\ 0 \\ +1 \end{bmatrix}$$

(+)

SISTEMA REDUZIDO:

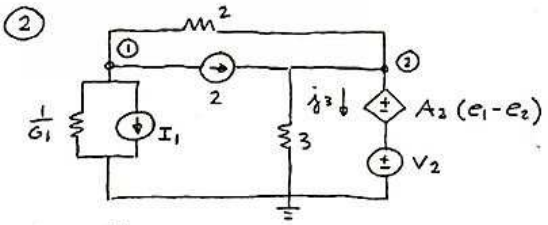
$$\begin{bmatrix} s+2 & -1 & -s \\ -1 & s+1 & 0 \\ 0 & \frac{3}{2} & -\frac{1}{2} \end{bmatrix} \begin{bmatrix} E_1(s) \\ E_{23}(s) \\ E_4(s) \end{bmatrix} = \begin{bmatrix} -1 \\ 0 \\ 0 \end{bmatrix}$$

$$E_4(s) = \frac{\frac{3}{2}}{(s^2+3s+2)\left(-\frac{1}{2}\right) + \frac{3}{2}s + \frac{1}{2}} = \frac{-3}{s^2+1}$$

$$v_o(t) = -3\,\mathrm{sen}\,t$$

VERIFICAÇÃO SIMPLES: $v_o(0) = 0$, DEVIDO AO CAPACITOR DESCARREGADO NO NÓ 2

②



$$G_1 = -2 \quad e_{1M} = -2$$

$$I_1 = 1 - e_{1M}^2 + 2e_{1M} = 2$$

$$A_2 = 3(e_{1M} - e_{2M})^2 = 3$$

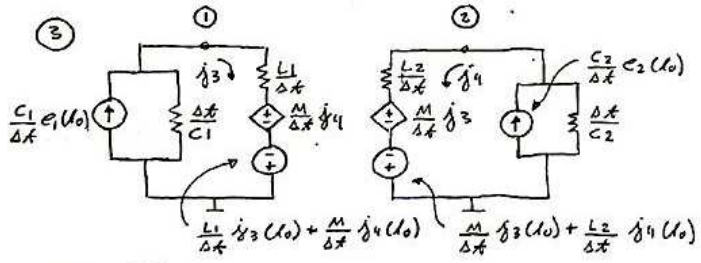
$$V_2 = (e_{1M} - e_{2M})^3 - 3(e_{1M} - e_{2M}) = -1 - 3(-1) = 2$$

$$e_{2M+1} = A_2(e_{1M+1} - e_{2M+1}) + V_2$$

SISTEMA:

$$\begin{matrix} & 1 & 2 & 3 \\ 1 & \frac{1}{2}-2 & -\frac{1}{2} & 0 \\ 2 & -\frac{1}{2} & \frac{1}{2}+\frac{1}{3} & 1 \\ 3 & 3 & -3-1 & 0 \end{matrix} \begin{bmatrix} e_{1M+1} \\ e_{2M+1} \\ j_{3M+1} \end{bmatrix} = \begin{bmatrix} -2-2 \\ +2 \\ -2 \end{bmatrix}$$

③

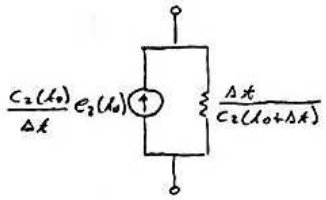


$$M = k\sqrt{L_1 L_2} = 6$$

$$\begin{matrix} & 1 & 2 & 3 & 4 \\ 1 & \frac{1}{\Delta t} & 0 & 1 & 0 \\ 2 & 0 & \frac{1}{100\Delta t} & 0 & 1 \\ 3 & -1 & 0 & \frac{1}{\Delta t} & \frac{6}{\Delta t} \\ 4 & 0 & -1 & \frac{6}{\Delta t} & \frac{100}{\Delta t} \end{matrix} \begin{bmatrix} e_1(t_0+\Delta t) \\ e_2(t_0+\Delta t) \\ j_3(t_0+\Delta t) \\ j_4(t_0+\Delta t) \end{bmatrix} =$$

$$= \begin{bmatrix} \frac{1}{\Delta t} e_1(t_0) \\ \frac{1}{100\Delta t} e_2(t_0) \quad ** \\ \frac{1}{\Delta t} j_3(t_0) + \frac{6}{\Delta t} j_4(t_0) \\ \frac{6}{\Delta t} j_3(t_0) + \frac{100}{\Delta t} j_4(t_0) \end{bmatrix}$$

SE C_2 VARIAR NO TEMPO, SEU MODELO PASSA A SER



O TERMO * PASSA A SER $\dfrac{C_0 + a(t_0+\Delta t)}{\Delta t}$

O TERMO ** PASSA A SER $\dfrac{C_0 + a t_0}{\Delta t}\, e_2(t_0)$