

ELETRÔNICA DE POTÊNCIA

CIRCUITOS CHAVEADOS BÁSICOS

(REVISÃO)

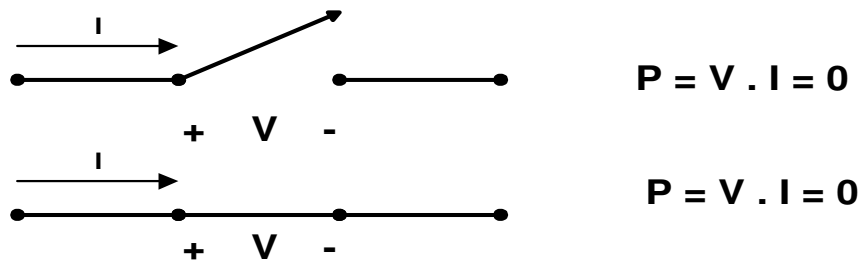
PRIMEIRO SEMESTRE DE 2005

CIRCUITOS CHAVEADOS BÁSICOS

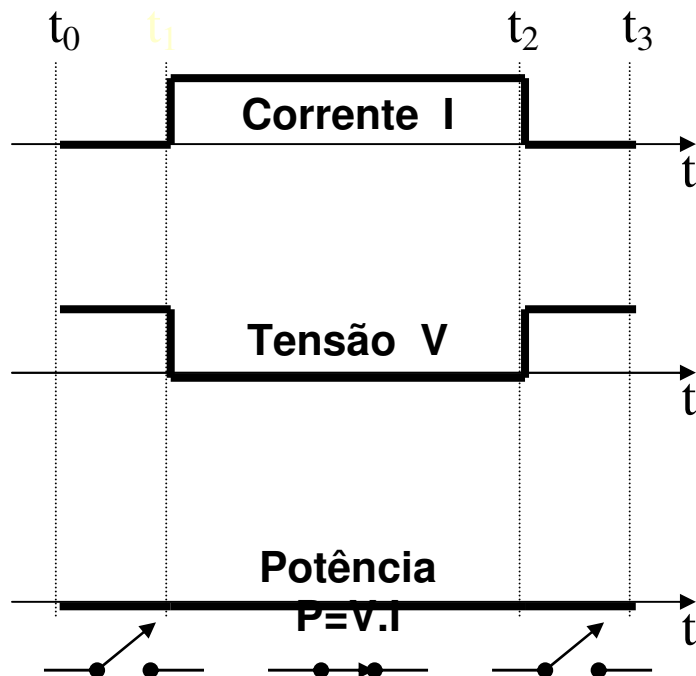
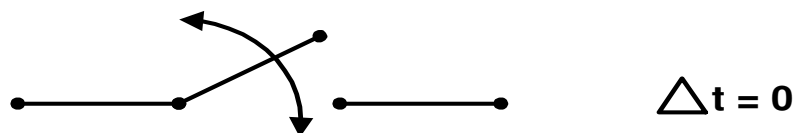
(REVISÃO)

I. CHAVE IDEAL – Revisão do conceito

CARACTERÍSTICAS ESTÁTICAS

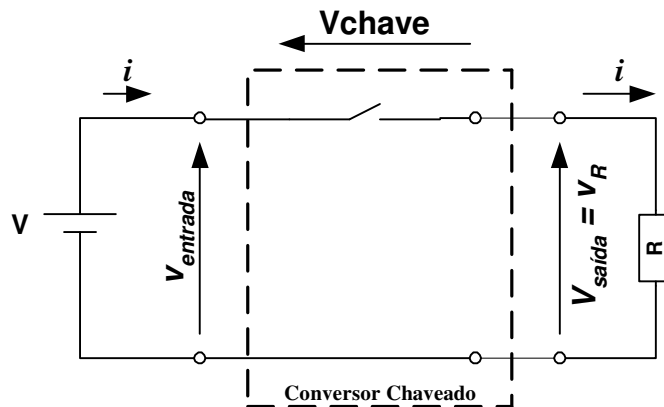


CARACTERÍSTICAS DINÂMICAS

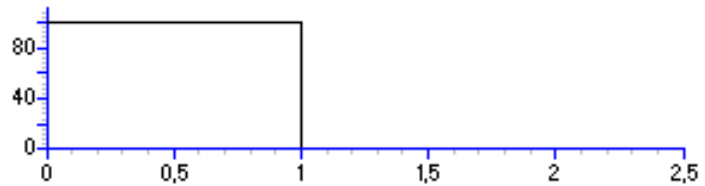


II. CHAVEAMENTO COM FONTES CC

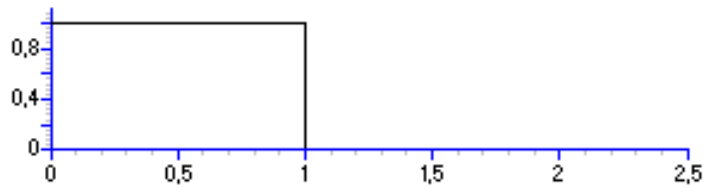
1. CARGA PURAMENTE RESISTIVA



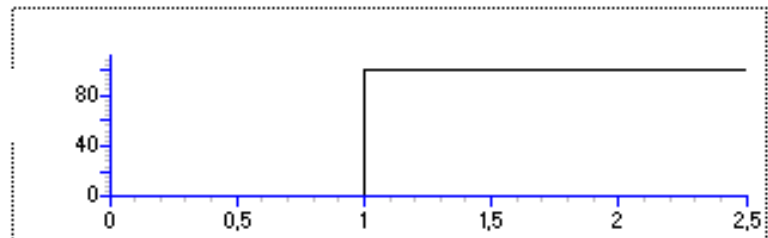
Tensão em R



Corrente no circuito



Tensão na chave



EQUACÕES

$$V_{entrada} = V = v_s + v_R$$

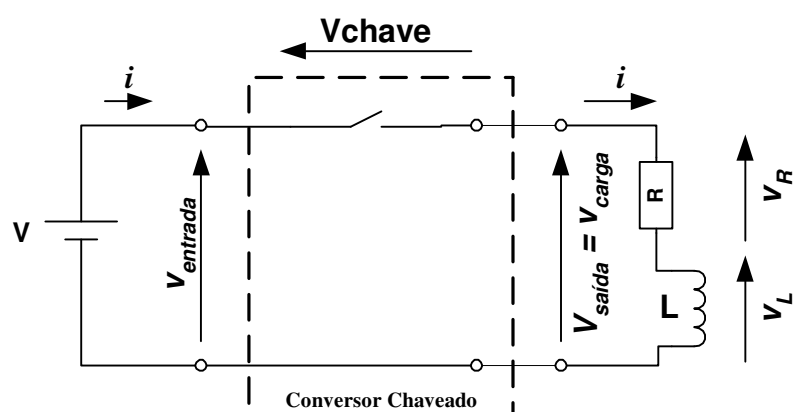
$$v_R = R \cdot i \Rightarrow i = v_R / R$$

$$v_{chave} = V - v_R$$

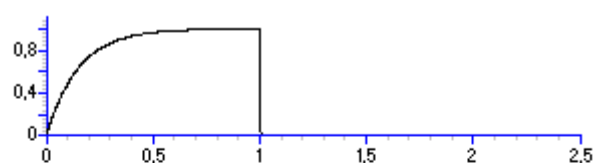
Chave aberta: $i = 0$

Chave fechada: $v_s = 0$

2. CARGA INDUTIVA – RL série.



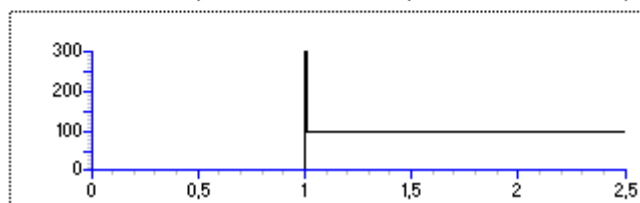
Corrente no circuito



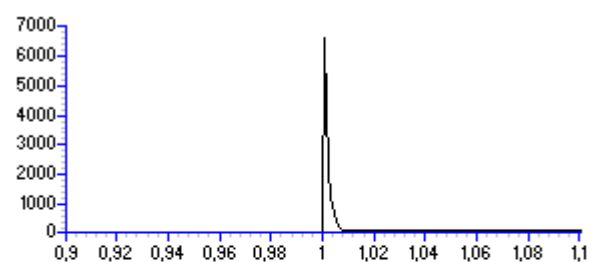
Tensão em L



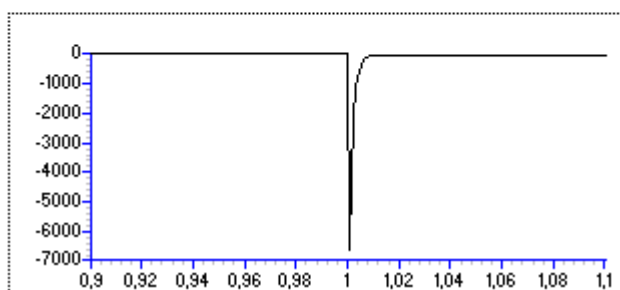
Tensão na chave



Tensão na chave - detalhe



Tensão em L - detalhe



EQUAÇÕES

$$V_{entrada} = V = v_s + v_{saída}$$

$$v_R = R \bullet i$$

$$v_L = L \bullet \frac{di}{dt}$$

$$i = i_{RP} + i_{TR} = \frac{V}{R} \left(1 - e^{-(R/L)t} \right)$$

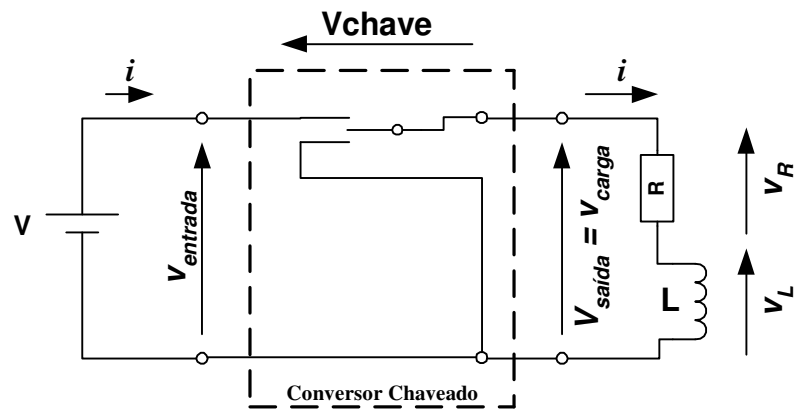
$$v_{saída} = v_R + v_L$$

$$v_{chave} = V - v_{saída}$$

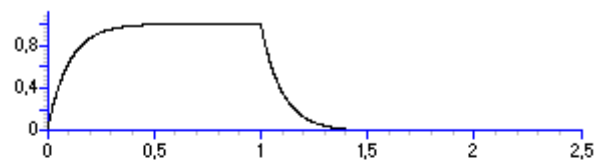
Chave aberta: $i = 0$

Chave fechada: $v_s = 0$

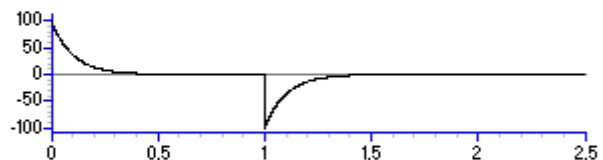
3. CARGA INDUTIVA – RL série/chave paralela.



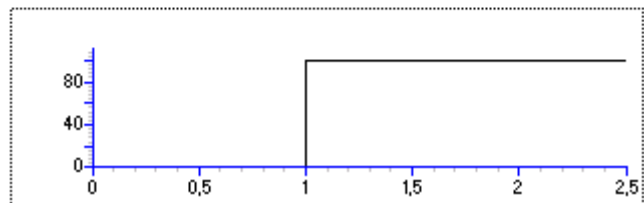
Corrente no circuito



Tensão em L



Tensão na chave



EQUACÕES

$V_{entrada} = V = v_s + v_{saida}$ para V conectado

$v_{saida} = 0$ para V desconectado

$$v_R = R \cdot i$$

$$v_L = L \cdot \frac{di}{dt}$$

$$i = i_{RP} + i_{TR} = \frac{V}{R} (1 - e^{-(R/L)t})$$

para V conectado

$$i = i_{TR} = \frac{V}{R} (e^{-(R/L)t})$$

para V desconectado

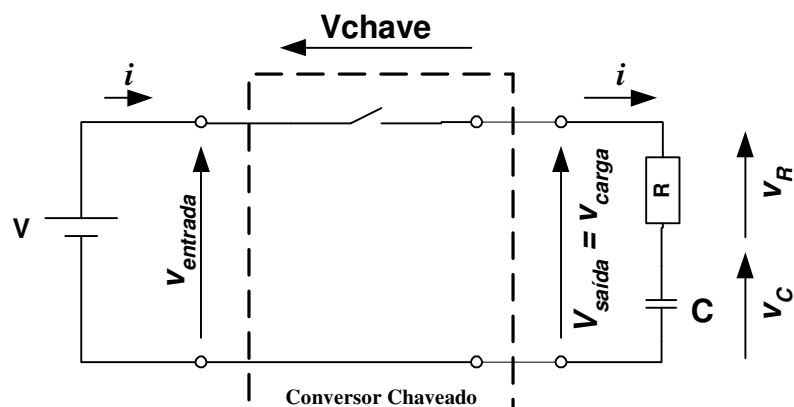
$$v_{saida} = v_R + v_L$$

$$v_{chave} = V - v_{saida}$$

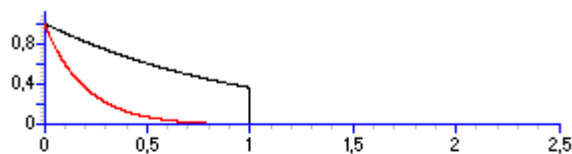
Chave aberta: $i = 0$

Chave fechada: $v_s = 0$

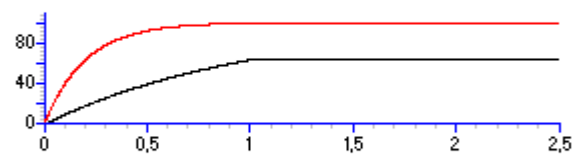
4. CARGA CAPACITIVA – RC série.



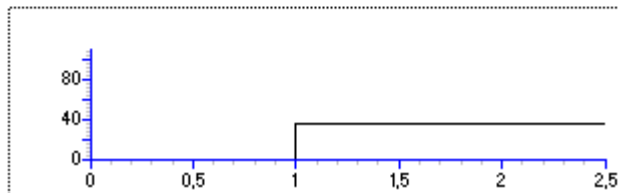
Corrente no circuito



Tensão no capacitor



Tensão na chave



EQUAÇÕES

$$V_{entrada} = V = v_s + v_{saida}$$

$$v_C = V \cdot (1 - e^{-t/R.C})$$

$$v_R = R \cdot i$$

$$v_{chave} = V - v_{saida}$$

$$v_C = \frac{1}{C} \cdot \int i \cdot dt + v_C(0)$$

Chave aberta: $i = 0$

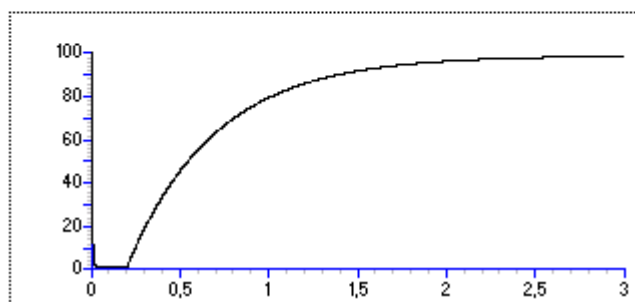
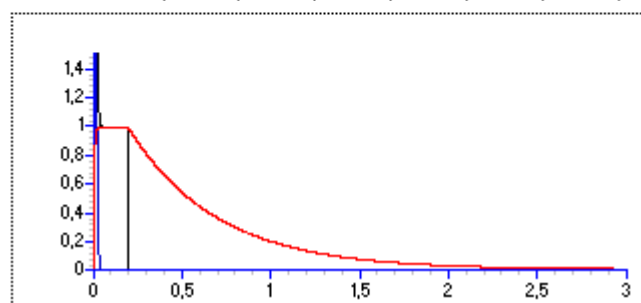
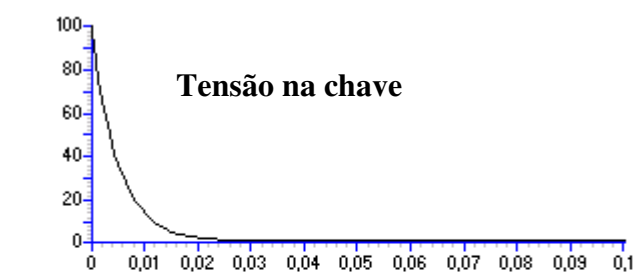
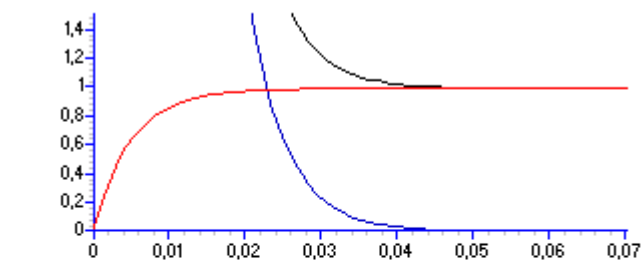
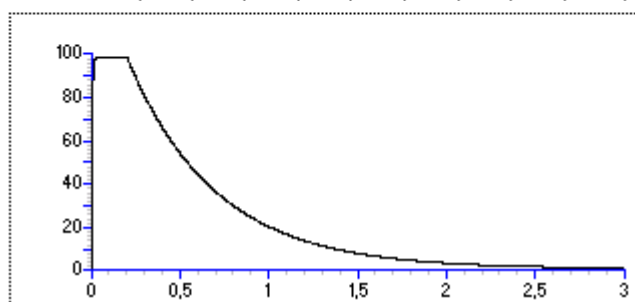
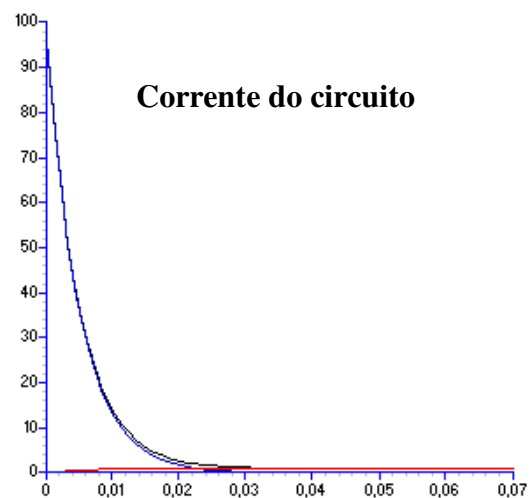
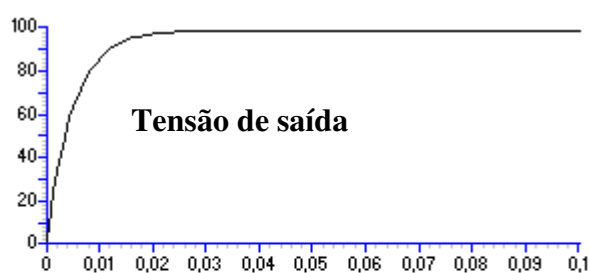
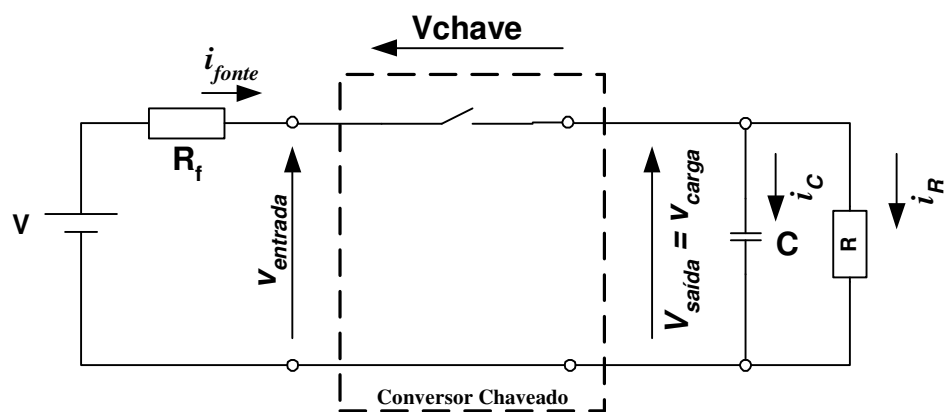
Chave fechada: $v_s = 0$

$$v_{saida} = v_R + v_C$$

$$\frac{di}{dt} + \frac{1}{RC} \cdot i = 0$$

$$i = i_{TR} = \frac{V}{R} \cdot e^{-t/R.C}$$

5. CARGA CAPACITIVA – RC paralelo.



EQUAÇÕES

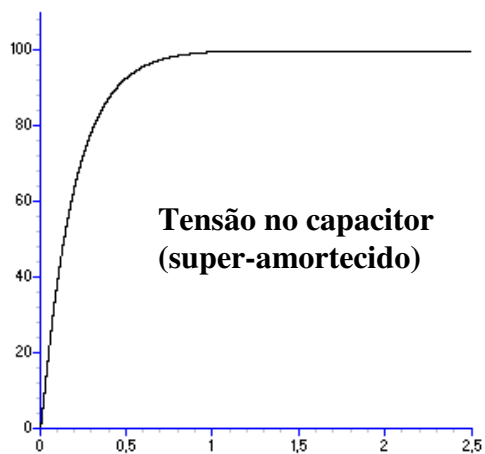
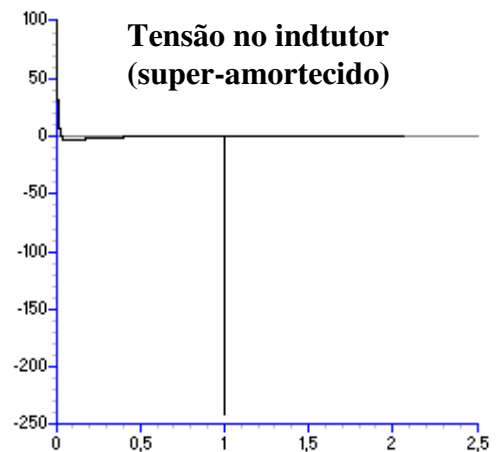
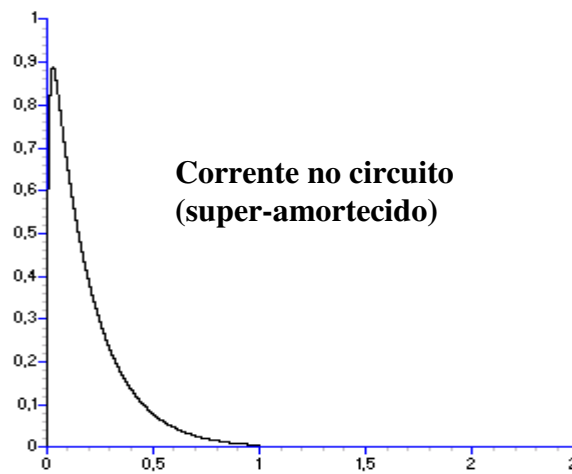
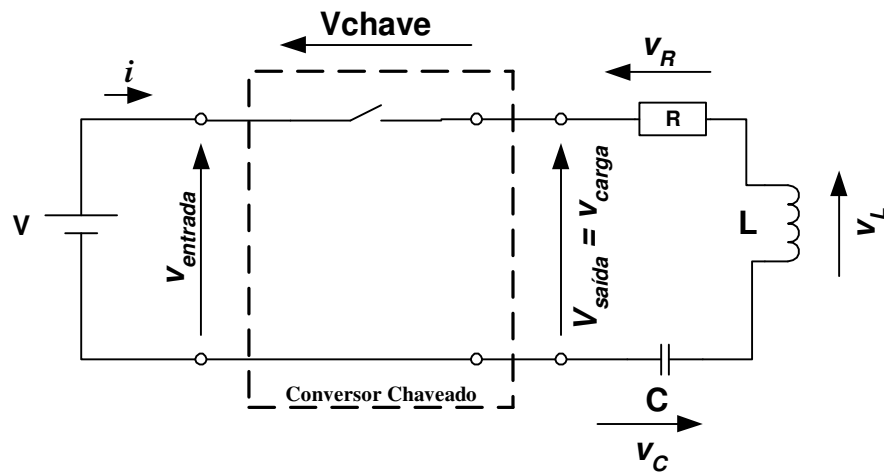
$$V_{entrada} = V = v_{Rf} v_s + v_{saída}$$

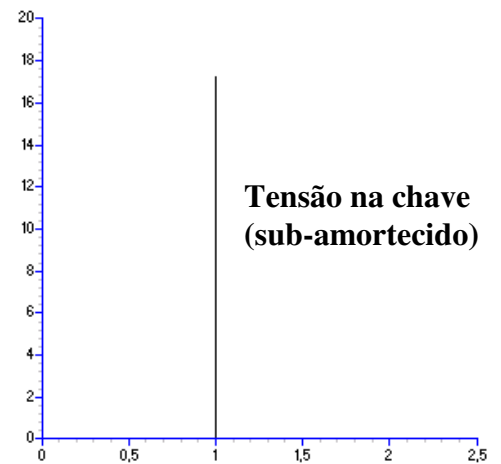
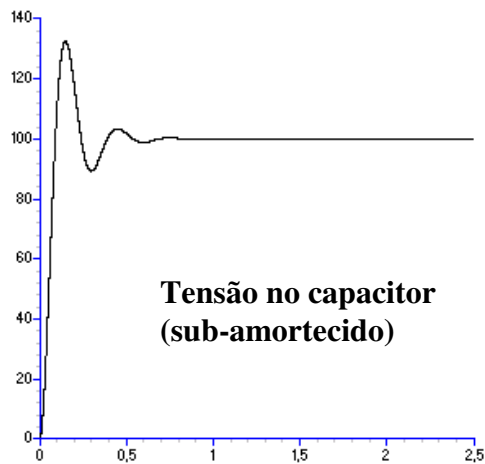
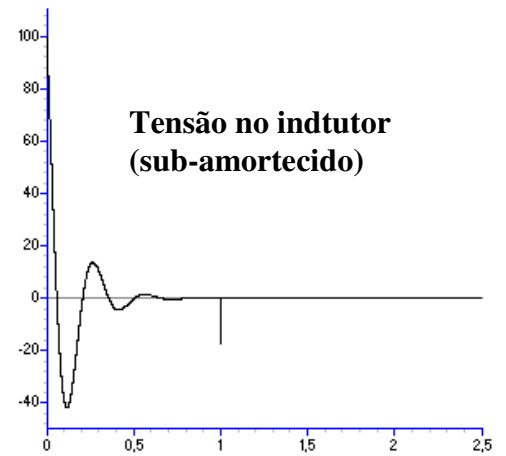
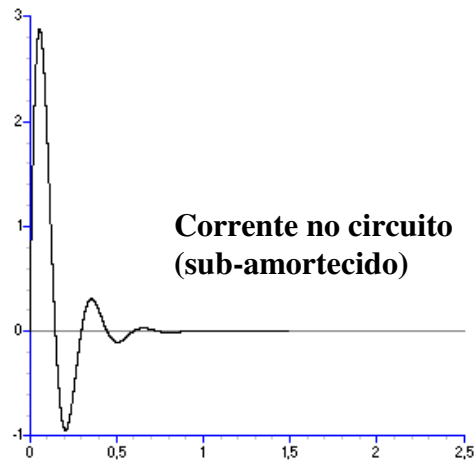
$$v_C = \frac{1}{C} \bullet \int i_C . dt + V_C(0) = v_R = R \bullet i_R$$

$$i_{fonte} = i_R + i_C$$

$$\frac{d}{dt} \begin{bmatrix} v_C \\ i_R \end{bmatrix} = \begin{bmatrix} \frac{-1}{R_f . C} & \frac{-1}{C} \\ \frac{-1}{R_f . R . C} & \frac{-1}{R . C} \end{bmatrix} \bullet \begin{bmatrix} v_C \\ i_R \end{bmatrix} + \begin{bmatrix} \frac{-1}{R_f . C} \\ \frac{-1}{R_f . R . C} \end{bmatrix} \bullet V$$

6. CARGA RLC série.





EQUAÇÕES

$$V_{entrada} = V = v_s + v_{saída}$$

$$v_R = R \cdot i$$

$$v_C = \frac{1}{C} \cdot \int i \cdot dt + V_C(0)$$

$$v_L = L \cdot \frac{di}{dt}$$

$$v_{saída} = v_R + v_C + v_L$$

$$\frac{d^2 i}{dt^2} + \frac{R}{L} \cdot \frac{di}{dt} + \frac{1}{LC} \cdot i = 0$$

$$\frac{d^2 i}{dt^2} + 2\zeta \cdot \frac{di}{dt} + \omega_n^2 \cdot i = 0$$

$$i = i_{TR} = A_1 \cdot e^{\sqrt{\zeta^2 - \omega_n^2} \cdot t} + A_2 \cdot e^{-\sqrt{\zeta^2 - \omega_n^2} \cdot t}$$

para o caso sub-amortecido:

$$i = i_{TR} = e^{-\zeta \cdot t} [B_1 \cdot \cos(\omega_r t) + B_2 \cdot \text{sen}(\omega_r t)]$$

$$\omega_r = \sqrt{\omega_n^2 - \zeta^2}$$

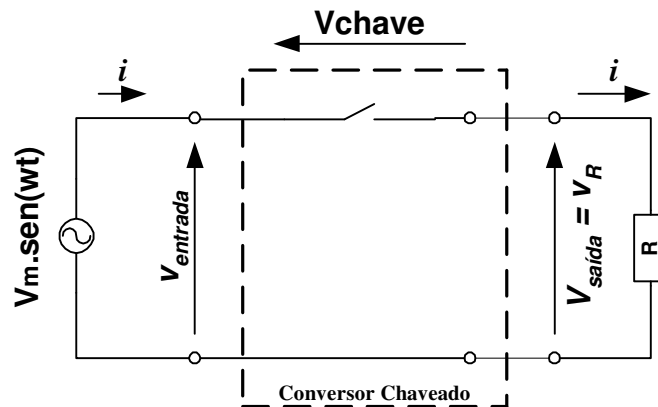
$$v_{chave} = V - v_{saída}$$

Chave aberta: $i = 0$

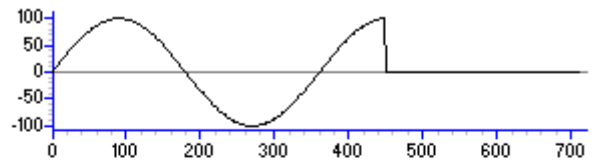
Chave fechada: $v_s = 0$

II. CHAVEAMENTO COM FONTES CA

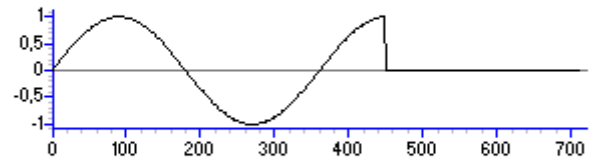
1. CARGA PURAMENTE RESISTIVA



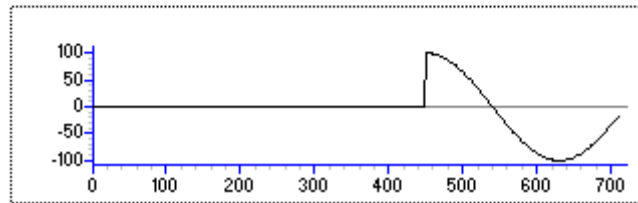
Tensão em R



Corrente no circuito



Tensão na chave



EQUACÕES

$$V_{entrada} = V_m \cdot \sin(\omega t) = v_s + v_R$$

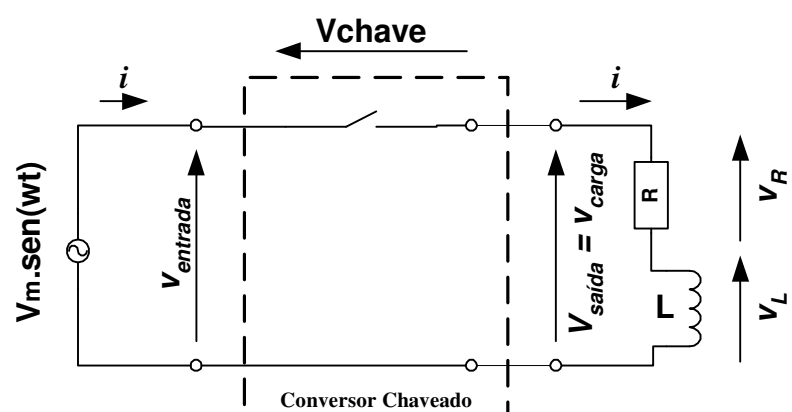
$$v_R = R \cdot i \Rightarrow i = v_R / R$$

$$v_{chave} = V - v_R$$

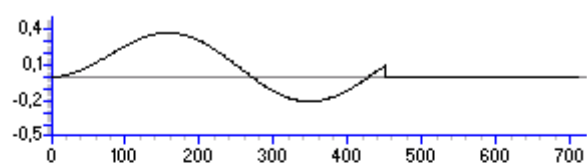
Chave aberta: $i = 0$

Chave fechada: $v_s = 0$

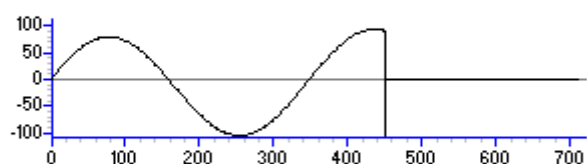
7. CARGA INDUTIVA – RL série.



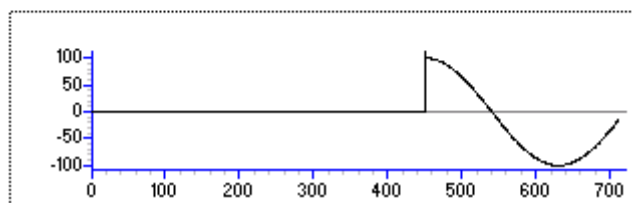
Corrente no circuito



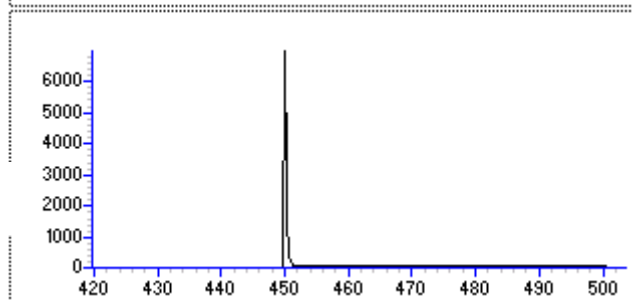
Tensão em L



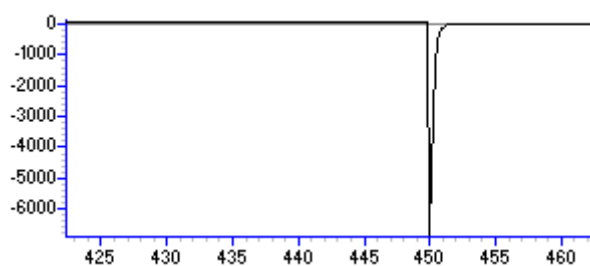
Tensão na chave



Tensão na chave - detalhe



Tensão em L - detalhe



EQUAÇÕES

$$V_{entrada} = V_m \bullet \text{sen}(\omega t) = v_s + v_{saída}$$

$$v_R = R \bullet i$$

$$v_L = L \bullet \frac{di}{dt}$$

$$v_{saída} = v_R + v_L$$

$$i = i_{RP} + i_{TR} = \frac{V_m}{Z} \bullet \text{sen}(\omega t - \Phi) + \frac{V_m}{Z} \text{sen} \Phi \bullet e^{-\omega t / \tan \Phi}$$

$$Z = \sqrt{R^2 + (\omega L)^2}$$

$$\tan \Phi = \frac{\omega L}{R}$$

$$v_{chave} = V - v_{saída}$$

Chave aberta: $i = 0$

Chave fechada: $v_s = 0$