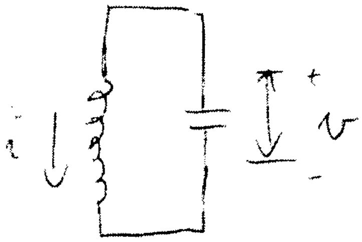
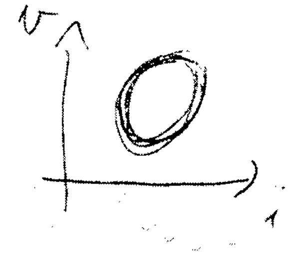
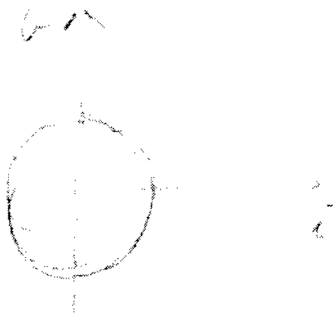
~~• potméter~~

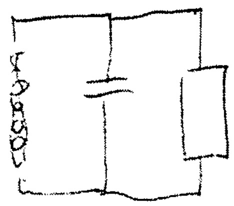
~~• mikro~~ - csavarhúzó

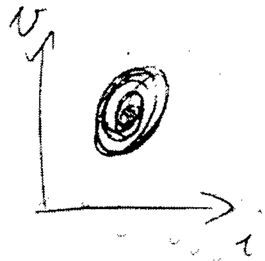
Chua

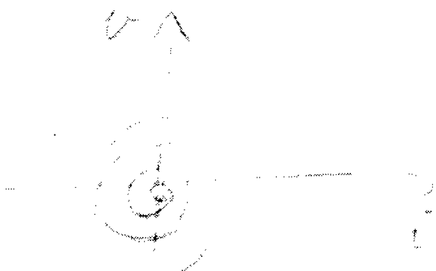






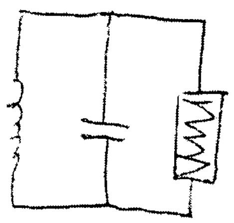






• disszipáció: energia elvesztése

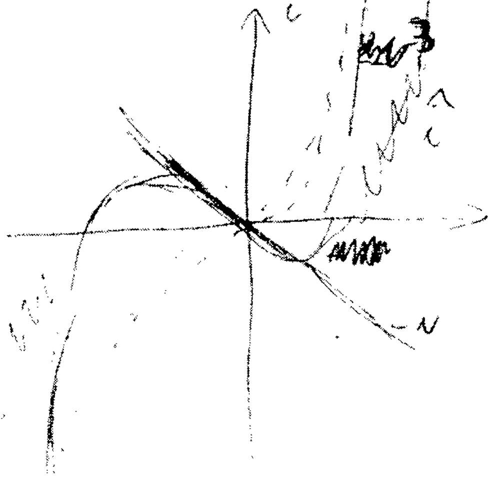
↳ valós rendszerben mindig van



→ aktív, nemlineáris elem

$\hat{i} = -v + kv^3$

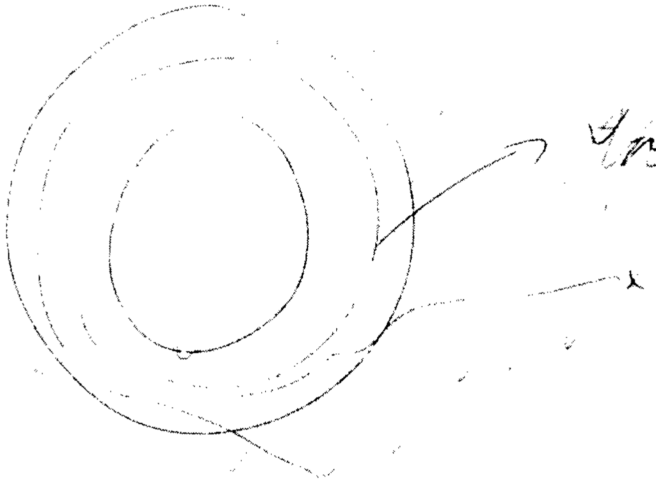
(egyébként $\hat{i} \sim v$, így $-v$ miatt áramot viszünk vissza a rendszerbe.)



• nem engedi a rendszert „felrobbanni”, „elszállni”, ha nagy a feszültség

• növeli az áramot, ha az kicsi

Káosz:



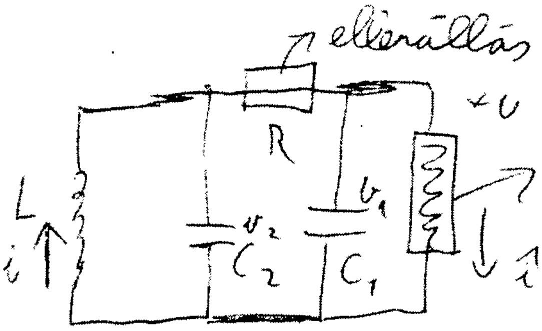
Spirál lejárása itt

⇓

legalább 3 dimenzióra lesz szükség

⇓

még egy ~~...~~ elem az áramkörbe



aktív, hogy oszcillátor legyen

$\hat{i}(v) = -g_1 v + g_3 v^3$

• Chua, 1983

$$\frac{dv_2}{dt} = \frac{1}{C_2}\Big(i - \overbrace{\frac{v_2 - v_1}{R}}^{i_0}\Big) = \frac{1}{C_2}\text{(a kondenzátoron „átfolyó" áram)}$$

$$\frac{dv_1}{dt} = \frac{1}{C_1}\Big(-\hat{i}(v) + \underbrace{\frac{v_2 - v_1}{R}}_{i_0}\Big) = \frac{1}{C_1}(-\hat{i} + i_0)$$

$$\frac{di}{dt} = -\frac{1}{L} v_2$$

→ párhuzamosan van kapcsolva C_1-el így ugyanannyi áram esik rajta.

→ A v_2 kondenzátort tölti a tekercsen átfolyó áram

$$i_0 = \frac{v_2 - v_1}{R}$$

$$\tau = \frac{t}{RC_2}$$

$$x_1 = v_1$$

$$x_2 = v_2$$

$$x_3 = Ri$$

$$\alpha = \frac{C_2}{C_1}$$

$$\beta = \frac{R^2 C_2}{L}$$

$$f(v) = -g_1 v + g_3 v^3 =$$

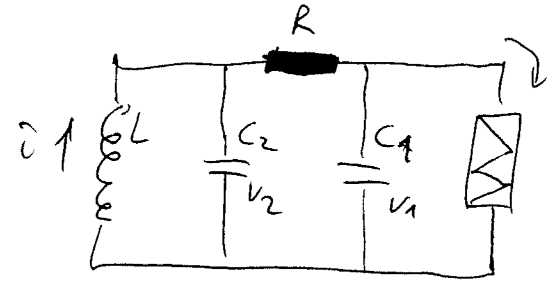
$$= -g_1 R v + g_3 R v^3 =$$

$$= R\, \tilde{i}(v)$$

$$\frac{dx_1}{d\tau} = -\alpha x_1 + \alpha x_2 - \alpha f(x_1)$$

$$\frac{dx_2}{d\tau} = x_1 - x_2 + x_3$$

$$\frac{dx_3}{d\tau} = -\beta x_2$$



$$\hat{i} = \hat{i}(v_1) = -g_1 v_1 + g_3 v_1^3$$

$$\left.\begin{aligned}
\frac{dv_2}{dt} &= \frac{1}{C_2}\left(i - \frac{v_2 - v_1}{R}\right) \\
\frac{dv_1}{dt} &= \frac{1}{C_1}\left(-\hat{i}(v_1) + \frac{v_2 - v_1}{R}\right) \\
\frac{di}{dt} &= -\frac{1}{L} v_2
\end{aligned}\right\}$$

$$u(t) = L \frac{d\, i(t)}{dt}$$

$$C = \frac{Q}{U}$$

akkor $i(t) = C \cdot u(t)$

egyenlet-transzformálás

$$\tau = \frac{t}{RC_2} \qquad \alpha = \frac{C_2}{C_1}$$

$$x_1 = v_1 \qquad \beta = \frac{R^2 C_2}{L}$$

$$x_2 = v_2$$

$$x_3 = R \cdot i \qquad f(x) := -R g_1 x + R g_3 x^3$$

$$\frac{dx_1}{d\tau} = -\alpha x_1 + \alpha x_2 - \alpha \cancel{R} f(x_1)$$

!

$$\frac{dx_2}{d\tau} = x_1 - x_2 + x_3$$

$$\frac{dx_3}{d\tau} = -\beta x_2$$

I.

$$\frac{dx_1}{d\tau}\cdot\frac{1}{RC_2}=\frac{1}{C_1}\cdot\left(-\left(-q_1x_1+q_3x_1^3\right)+\frac{x_2-x_1}{R}\right)$$

$$\frac{dx_1}{d\tau}=\frac{\cancel{R}C_2}{C_1}\cdot\left(-f(x_1)\right)+\frac{C_2}{C_1}\cdot x_2-\frac{C_2}{C_1}\cdot x_1$$

$$\underline{\frac{dx_1}{d\tau}=-\alpha x_1+\alpha x_2-\cancel{R}\alpha f(x_1)}$$

II.

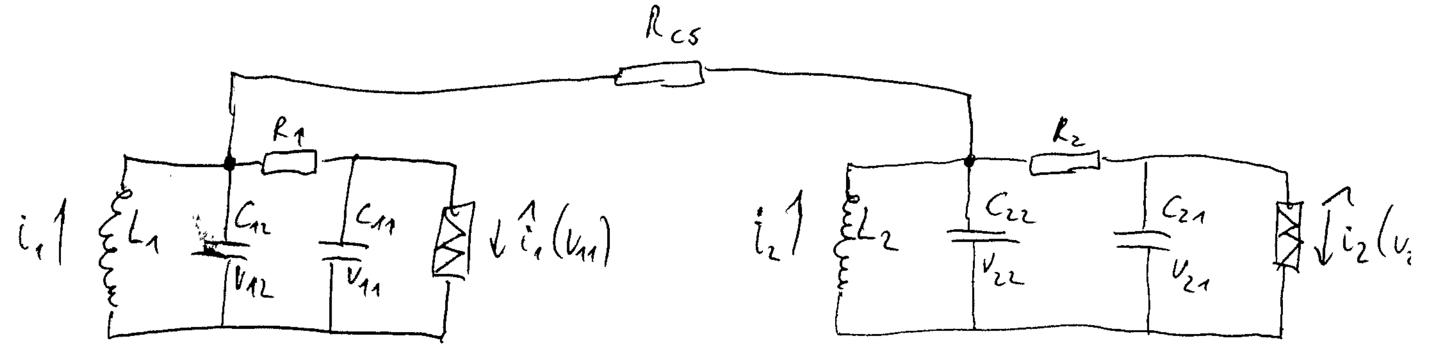
$$\frac{dx_2}{d\tau}\cdot\frac{1}{\cancel{RC_2}}=\frac{1}{\cancel{C_2}}\left(\frac{x_3}{\cancel{R}}-\frac{x_2-x_1}{\cancel{R}}\right)$$

$$\underline{\frac{dx_2}{d\tau}=x_1-x_2+x_3}$$

III.

$$\frac{dx_3}{d\tau}\cdot\frac{1}{R^2C_2}=-\frac{1}{L}x_2$$

$$\frac{dx_3}{d\tau}=-\frac{R^2C_2}{L}x_2=-\beta x_2$$



$$\frac{dv_{11}}{dt} = \frac{1}{C_{11}}\left(-\hat{i}_1 + \frac{v_{12}-v_{11}}{R_1}\right)$$

$$\frac{dv_{12}}{dt} = \frac{1}{C_{12}}\left(i_1 - \frac{v_{12}-v_{11}}{R_1} - \frac{v_{12}-v_{22}}{R_{cs}}\right)$$

→ feltéve, hogy R_{cs}-n az áram → irányban folyik

$$\frac{di_1}{dt} = -\frac{1}{L_1} v_{12}$$

$$\frac{dv_{21}}{dt} = \frac{1}{C_{21}}\left(-\hat{i}_2 + \frac{v_{22}-v_{21}}{R_2}\right)$$

$$\frac{dv_{22}}{dt} = \frac{1}{C_{22}}\left(i_2 - \frac{v_{22}-v_{21}}{R_2} + \frac{v_{12}-v_{22}}{R_{cs}}\right)$$

$$\frac{di_2}{dt} = -\frac{1}{L_2} v_{22}$$

- Ugyanolyan áramköri elemek:

$$C_{11} = C_{21} = C_1$$
$$C_{12} = C_{22} = C_2$$
$$L_1 = L_2 = L$$
$$R_1 = R_2 = R$$
$$\hat{i}_1(v) = \hat{i}_2(v)$$ // a függvény egyforma (nemlinearitás)

$$\tau = \frac{t}{RC_2} \qquad \alpha = \frac{C_2}{C_1}$$

$$x_1 = v_{11} \qquad \beta = \frac{R^2 C_2}{L}$$

$$x_2 = v_{12}$$

$$x_3 = R i_1 \qquad \hat{i}_\bullet(v) = -g_1 v + g_3 v^3 \qquad f(x) := -R g_1 (x) + R \ldots$$

$$x_4 = v_{21}$$

bit 1 or 2 ; (R muss bedeutung)

$$x_5 = v_{22}$$

$$x_6 = R \cdot i_2 \qquad g_{cs} = \frac{R}{R_{cs}}$$

$$\frac{dx_1}{d\tau} = -\alpha x_1 + \alpha x_2 - \alpha \cancel{R} f(x_1)$$

$$\frac{dx_2}{d\tau} = x_1 - x_2 + x_3 - g_{cs}(x_2 - x_5) \Rightarrow$$

$$\frac{dx_2}{d\tau} \cdot \frac{1}{RC_2} = \frac{x_3}{C_2 R} - \frac{x_2 - x_1}{R \cdot C_2} - \frac{x_2 - x_5}{R_{cs} \cdot C_2}$$

$$\frac{dx_2}{d\tau} = x_3 - x_2 + x_1 - g_{cs}(x_2 \ldots$$

$$\frac{dx_3}{d\tau} = -\beta x_2$$

$$\frac{dx_4}{d\tau} = -\alpha x_4 + \alpha x_5 - \alpha \cancel{R} f(x_4)$$

$$\frac{dx_5}{d\tau} = x_4 - x_5 + x_6 + g_{cs}(x_2 - x_5) \Rightarrow$$

$$\frac{dx_5}{d\tau} \cdot \frac{1}{RC_2} = \frac{1}{C_2} \cdot \left(\frac{x_6}{R} - \frac{x_5 - x_4}{R} + R \frac{x_2 - x_5}{R_{cs}} \right)$$

$$\frac{dx_5}{d\tau} = x_6 - x_5 + x_4 + g_{cs}(x_2 - x_5 \ldots$$

$$\frac{dx_6}{d\tau} = -\beta x_5$$