MAE 3780/3783: Mechatronics
February 5, 2024

Logistics Updates

- This week in lab – **office hours**
  - **Lab 2** will occur next week – details released (including pre-lab) soon
- HW 2 (resistors) due **Friday, February 9, 11 pm**
- HW 3 (RLC) released asap – Due **Friday, February 23, 11 pm**
- Office hours schedule viewable on shared Google calendar

Let's add numbers!

$V_s = 3\,V$

$R_1 = 300\,\Omega$

$R_2 = 1\,k\Omega$

$R_3 = 100\,\Omega$

$I_s = 0\,A$

what is V_{R_3}?

from node analysis:

$$\begin{bmatrix} \frac{1}{300}+\frac{1}{100} & -\frac{1}{100} & 0 \\ \frac{1}{100} & -\left(\frac{1}{100}+\frac{1}{1000}\right) & 1 \\ 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} V_A \\ V_B \\ i \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 3 \end{bmatrix}$$

$$\begin{bmatrix} V_A \\ V_B \\ i \end{bmatrix} = \begin{bmatrix} \frac{9}{4}\ V \\ 3\ V \\ \frac{21}{2000}\ A \end{bmatrix}$$

$$V_{R_3} = V_A - V_B = \frac{9}{4} - 3$$

$$= -3/4\ V$$

Energy Storing Devices

capacitor: C —||— farad (f)

typically 1pf - 1mf

$$C_{tot} = C_1 + C_2 + \dots C_n \text{ (in parallel)}$$

$$\frac{1}{C_{tot}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots \frac{1}{C_n} \text{ (in series)}$$

I-V: $I_c = C \dfrac{dV_c}{dt}$

$$V_c(t) = \frac{1}{C} \int_{-\infty}^{t} I_c(t')\, dt'$$

given $V_c(t=t_0) = V_0$ then

$$V_c(t) = \frac{1}{C}\int_{t_0}^{t} I_c(t')\,dt' + V_0$$

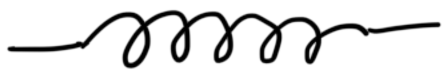
$$\forall t \geq t_0$$

properties:

- at steady state, $I_c(t \to \infty) = 0$ (open circuit)
- continuity: V_c <u>cannot</u> jump

$$V_c(t^-) = V_c(t^+)$$

I_c can jump

inductor: L  Henry (H)

$L_{tot} = L_1 + L_2 + \dots L_N$ (in series)

$\frac{1}{L_{tot}} = \frac{1}{L_1} + \frac{1}{L_2} + \dots \frac{1}{L_N}$ (in parallel)

I-V: $V_L = L \frac{dI_L}{dt}$

$$I_L(t) = \frac{1}{L} \int_{-\infty}^{t} V_L(t')\,dt'$$

given $I_L(t = t_0) = I_0$ then

$$I_L(t) = \frac{1}{L} \int_{t_0}^{t} V_L(t')\,dt' + I_0$$

$\forall\, t \geq t_0$

properties:

- at steady state $V_L(t \to \infty) = 0$
  (short circuit)

- continuity: I_L cannot jump

  $I_L(t^-) = I_L(t^+)$

  V_L can jump

circuit analysis:

① KVL, KCL, ohm's law to write ODE

② Solve ODE:

- bring to canonical form
- find initial condition
  $x(t=0) = x_0$
- find steady state
  $x(t \to \infty) = x_\infty$
- use formula in ODE handout

first order system:

$$\tau \frac{dx(t)}{dt} + x(t) = K_s F(t)$$

solution: $x(t) = (x_0 - x_\infty) e^{-\frac{t}{\tau}} + x_\infty$