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RLC Circuits

Properties and Definitions

2nd Order Circuits because their represented by 2nd order differentials equations
Natural Response is the response of the circuit without a power supply.
Step Response is the response of the power supply on the circuit.

Resonant Radian Frequency is a dependent on equivalent inductors and capacitors ($\omega_o = \sqrt{\frac{1}{LC}}$)

Neper Frequency measures the rate at which the transient response diminishes ($\frac{1}{2RC}$ or $\frac{R}{2L}$) - *PS*
Overdamped is when the Neper Frequency is greater than the Resonant Rad. Freq. ($\alpha^2 > \omega_o^2$)

- Standard form: $x(t) = x_f + A_1 e^{-s_1 t} + A_2 e^{-s_2 t}$
- $s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_o^2}$

Underdamped is when the Neper Frequency is less than the Resonant Rad. Freq. ($\alpha^2 < \omega_o^2$)

- Standard form: $x(t) = x_f + (A_1 \cos(\omega_d t) + A_2 \sin(\omega_d t))e^{-\alpha t}$
- $\omega_d = \sqrt{\omega_o^2 - \alpha^2}$

Critically damped is when the Neper Frequency is equal to Resonant Rad. Freq. ($\alpha^2 = \omega_o^2$)

- Standard form: $x(t) = x_f + A_1 t e^{-\alpha t} + A_2 e^{-\alpha t}$

Analysis Methods

Equivalent RLC

1) Find Neper and Resonant Rad. Frequencies. = $\alpha = \frac{1}{2RC}$ or $\frac{R}{2L}(par.ser.); \omega_o = \sqrt{\frac{1}{LC}}$
1) Capacitors: $v_{0-} = v_{0+}$, Inductors: $i_{0-} = i_{0+}$
2) Find X_f as $t \to \infty$
3) Compare Neper and Resonant Rad. Frequencies to find out response
    a. $\alpha^2 > \omega^2$
        i. Standard form: $x(t) = x_f + A_1 e^{-s_1 t} + A_2 e^{-s_2 t}$
        ii. $s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_o^2}$
    b. $\alpha^2 < \omega^2$
        i. Standard form: $x(t) = x_f + (A_1 \cos(\omega_d t) + A_2 \sin(\omega_d t))e^{-\alpha t}$
        ii. $\omega_d = \sqrt{\omega_o^2 - \alpha^2}$
    c. $\alpha^2 = \omega^2$
        i. Standard form: $x(t) = x_f + A_1 t e^{-\alpha t} + A_2 e^{-\alpha t}$
4) Calculate the coefficient giving known parameters (A_1 & A_2)

S-Domain Transforms

1) Find Initial conditions if capacitor or inductor is present.
    a. $v_c(0-) = v_c(0+)$ and $i_L(0-) = i_L(0+)$
2) Transform circuit to find impedance and transformed sourced values.
    a. Resistors don't change impedance (Z_R=R), Sources are divided by S.
    b. Capacitor impedances are inversely related to capacitance and are divided by S
        i. $Z_C = \frac{1}{RS}$

ii. Capacitor Series Voltage Source
1. $V_c = \frac{v_c(0)}{S}$
iii. Capacitors Reverse Parallel Current Source
1. $I_c = Cv_c(0)$
c. Inductor impedances are directly related to inductance and are multiplied by S.
i. $Z_L = LS$

3)
i. Inductors
ii.
iii. If an I.C. for a capacitor is zero
b. , ignore element source in transform.

4) Transform Circuit
a. If I.C. equal zero, drop the source in the transform
5) Solve
6) Partial Fraction
7) Inverse Laplace