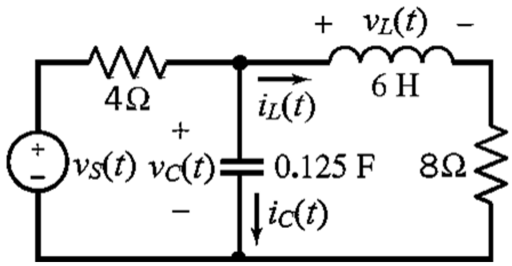
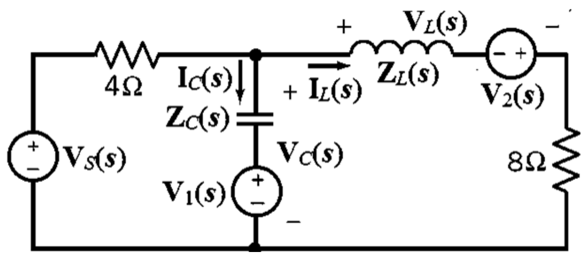
HOMEWORK #6: Laplace Transform Network Analysis

1. Sketching s-Domain Equivalents of Time-Domain Networks

Consider the second order network shown below with $v_S(t) = 24 - 36u(t)$.



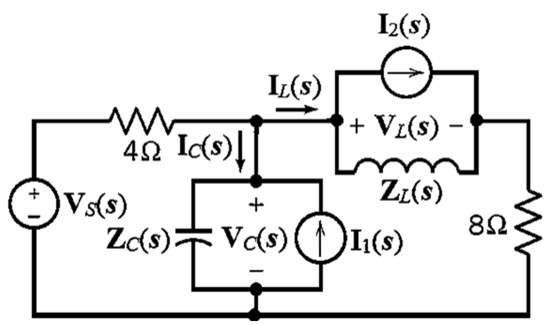
(a) The network below depicts the s-Domain equivalent of the 2nd order network with each energy storage element replaced by its <u>Thevenin model</u>.



Compute the following:

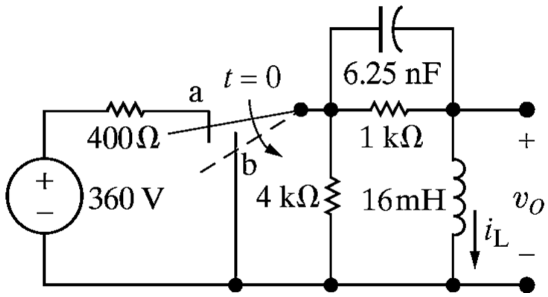
i. $\boldsymbol{V_S(s)}$ ii. $\boldsymbol{Z_C(s)}$ and $\boldsymbol{Z_L(s)}$ iii. $\boldsymbol{V_1(s)}$ and $\boldsymbol{V_2(s)}$

(b) The network shown depicts the s-Domain model of the 2nd network with each energy storage element replaced by its <u>Norton model</u>. Compute $\boldsymbol{I_1(s)}$ and $\boldsymbol{I_2(s)}$.



2. $\boldsymbol{s}$-Domain Analysis of Networks with Initial Conditions

(a) Consider the second order network below. The switch moves to position (b) at $t = 0$ after being at position (a) for a long time.



i. Draw the $\boldsymbol{s}$-Domain equivalent network valid for $t > 0^-$.

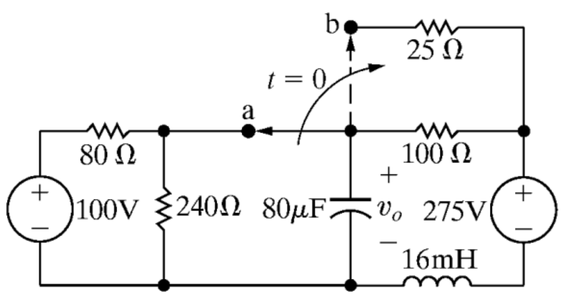
ii. Compute $\boldsymbol{V_o(s)}$, the Laplace Transform of the complete response voltage $v_o(t)$ for $t > 0^-$.

iii. Compute $\boldsymbol{I_L(s)}$, the Laplace Transform of the complete response current $i_L(t)$ for $t > 0^-$.

iv. Compute the complete response voltage $v_o(t)$ for $t > 0^-$. Identify the transient response portion $v_{o,TR}(t)$ and steady state response portion $v_{o,SS}(t)$ of $v_o(t)$. Is the transient response un-damped, under-damped, critically-damped, or over-damped?

v. Compute the complete response current $i_L(t)$ for $t > 0^-$. Identify the transient response portion $i_{L,TR}(t)$ and steady state response portion $i_{L,SS}(t)$ of $i_L(t)$. Is the transient response un-damped, under-damped, critically-damped, or over-damped?

(b) Consider the second order network below. The switch moves to position (b) at $t = 0$ after being in position (a) for a long time.

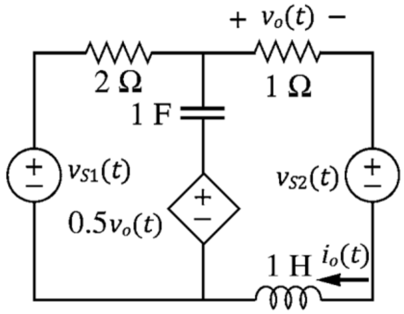


i. Draw the $\boldsymbol{s}$-Domain equivalent network valid for $t > 0^-$.

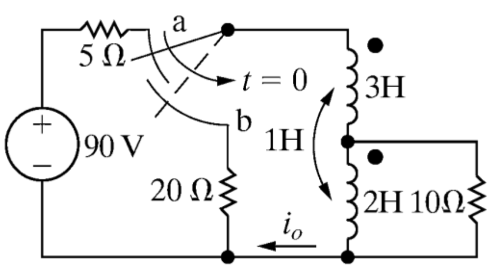
ii. Compute $\boldsymbol{V_o(s)}$, the Laplace Transform of the complete response voltage $v_o(t)$ for $t > 0^-$.

iii. Compute the complete response voltage $v_o(t)$ for $t > 0^-$. Identify the transient response portion $v_{o,TR}(t)$ and steady state response portion $v_{o,SS}(t)$ of $v_o(t)$. Is the transient response un-damped, under-damped, critically-damped, or over-damped?

(c) Consider the second order network shown below. The independent voltage sources have expressions $v_{S1}(t) = 5e^{-2t}u(t)\text{V}$ and $v_{S2}(t) = 3u(-t)\text{V}$. Compute the complete response current $i_o(t)$ for $t > 0^-$.

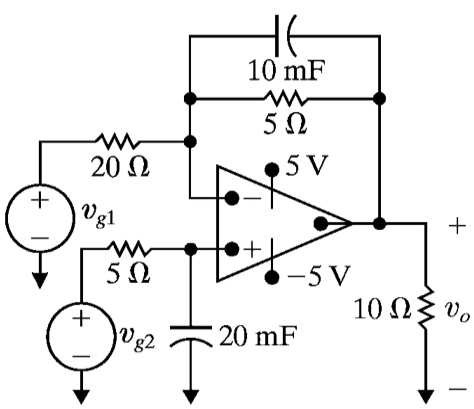


(d) Consider the magnetically coupled network shown below. The “make-before-break” switch moves to position (b) after being in position (a) for a long time. Compute the complete response current $i_o(t)$ for $t > 0^-$.



3. s-Domain Analysis of <u>Relaxed</u> Networks

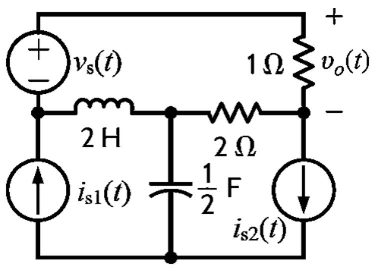
(a) Consider the second order <u>relaxed</u> ideal op-amp network with voltage source expressions $v_{g1}(t) = 40u(t)\text{V}$ and $v_{g2}(t) = 16u(t)\text{V}$.



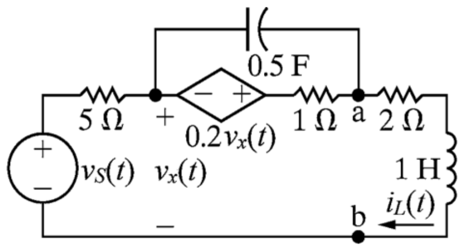
i. Compute the complete response voltage $v_o(t)$ for $t > 0^-$. Identify the transient response portion $v_{o,TR}(t)$ and steady state response portion $v_{o,SS}(t)$ of $v_o(t)$. Is the transient response un-damped, under-damped, critically-damped, or over-damped?

ii. Will the output voltage saturate? If so, at what time?

(b) Consider the second order relaxed network shown with source expressions $v_s(t) = 4u(t)\text{V}$, $i_{s1}(t) = e^{-2t}u(t)\text{A}$, and $i_{s2}(t) = 2u(t)\text{A}$. Apply Thevenin's Theorem to compute the complete response voltage $v_o(t)$ for $t > 0^-$. Assume the 1Ω resistor is the load network.



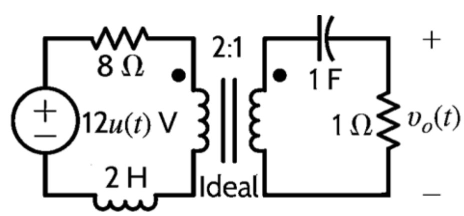
(c) Consider the second order <u>relaxed</u> network shown with $v_s(t) = 20u(t)\text{V}$.



i. Compute the s-Domain Thevenin impedance $\boldsymbol{Z_{TH}(s)}$ and Thevenin voltage $\boldsymbol{V_{TH}(s)}$,.

ii. Use the $\boldsymbol{s}$-Domain Thevenin equivalent network found in part (i) to compute the s-Domain load current $\boldsymbol{I_L(s)}$. Do not take the inverse Laplace transform of $\boldsymbol{I_L(s)}$.

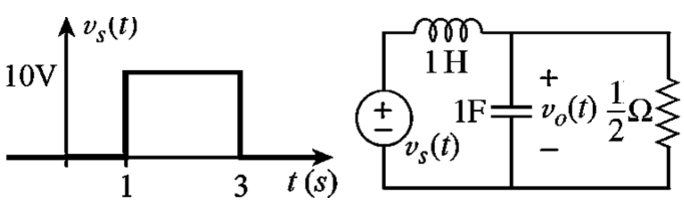
(d) Consider the second order <u>relaxed</u> ideal transformer network shown.



i. Reflect the primary $\boldsymbol{s}$-Domain equivalent network to the secondary of the transformer and compute $\boldsymbol{V_o(s)}$, the Laplace Transform of the complete response voltage $v_o(t)$ for $t > 0^-$.

ii. Compute the complete response voltage $v_o(t)$ for $t > 0^-$.

(e) Consider the 2nd order <u>relaxed</u> network shown below with $v_s(t)$ depicted by the plot.



i. Compute $\boldsymbol{V_s(s)}$, the Laplace Transform of the source voltage $v_s(t)$.

ii. Compute $\boldsymbol{V_o(s)}$, the Laplace Transform of the complete voltage response $v_o(t)$.

iii. Compute the complete voltage response $v_o(t)$ for $t > 0^-$. Identify the transient response portion $v_{o,TR}(t)$ and steady state response portion $v_{o,SS}(t)$ of $v_o(t)$. Is the transient response un-damped, under-damped, critically-damped, or over-damped?