EEL 3123C TEST 1 - DURATION: 60 minutes

1) Under a unit step input, the output of a circuit is given by $y(t) = \exp(-t)$ for time $t \geq 0$. Find the steady-state output under input given by $2\sin(t)$. (40)

For unit step input, $x(t) \Rightarrow X(s) = 1/s$ (5)

$y(t) = \exp(-t) \Rightarrow Y(s) = \frac{1}{s+1}$ (5) $\Rightarrow H(s) = \frac{Y(s)}{X(s)} = \frac{s}{s+1}$ (5)

$H(j\omega) = \frac{j\omega}{j\omega+1} = \frac{\omega}{\omega - j}$ (5) $\Rightarrow |H(j\omega)| = \frac{\omega}{\sqrt{1+\omega^2}}$ (5)

$\theta(j\omega) = +\tan^{-1}\left(\frac{1}{\omega}\right)$ (5)

$y_{s-s} = 2|H(j1)|\sin(t + \theta(j1))$ (10)

$= 2 \cdot \frac{1}{\sqrt{2}} \sin(t + \tan^{-1}(1))$

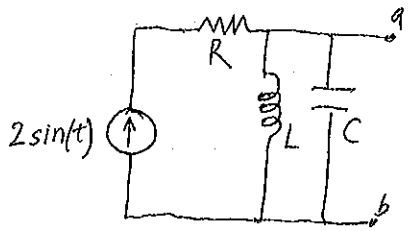
$= \sqrt{2}\sin(t + 45^\circ)$

2) Given $F(s) = \frac{5s^2 + 29s + 32}{s^2 + s - 1}$. Find $\lim_{t \to 0^+} f(t)$ and $\lim_{t \to \infty} f(t)$ by using, respectively, the initial and final value theorem if the respective limits exist. (20)

(10) IVT does not apply because $m = n = 2$, initial value DNE.

(10) FVT _____ because system is unstable, one root is in the RHP.

3) Looking through terminals a-b, obtain the Thevenin equivalent for the circuit. (30)



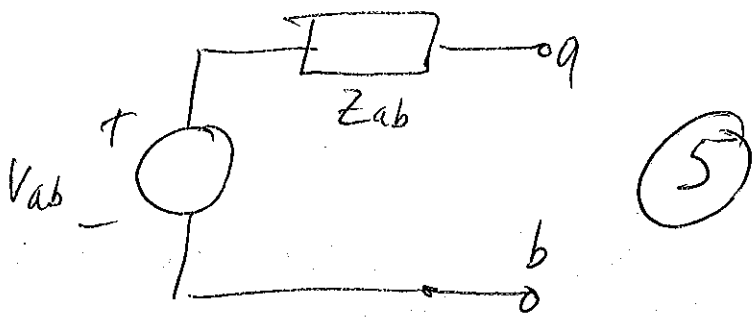
$R = L = C = 1$

$V_{ab} = I(s)\, Z(s)$

$I(s) = \frac{2}{s^2+1}$, $Z(s) = \frac{1}{sC} \,//\, sL = \frac{1}{\frac{1}{s}+s} = \frac{s}{s^2+1}$ (5)

$V_{ab}(s) = \frac{2s}{(s^2+1)^2}$ (10)

$Z_{ab} = \frac{s}{s^2+1}$ (5) (10)



(5)

4) Explain the concept of a virtual short for an ideal op-amp. Under what conditions does virtual-short hold? (10)

$V^+ = V^-$ ← virtual short. (5)

Holds under negative feedback (5)