TOTAL: ______/20

ECE 5548: Electronic Design I

Homework #1

Due: Monday, February 11th, 2019 (11pm)

Student Name: Thomas Collins

Note:
- **Please use this sheet as a cover page.**
- **Your work must be hand-written (no typing please).**
- **Homework must be submitted electronically through Canvas in a PDF format.**

Do the following problems from Nilsson & Riedel (11th edition)

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1. Example 13.12
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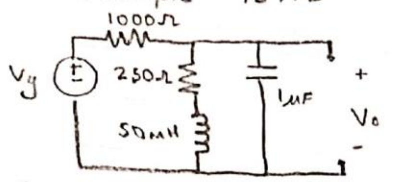
5. Problem 13.80

Thomas Collins
ECE 548
Due 2/11/2018

ECE 548

1. Example 13.12



$v_g = 120\cos(5000t + 30°)$ V

$Z_1 = 1000\,\Omega$

$Z_2 = 250\,\Omega$

$Z_3 = sL = j(5000 \cdot 50 \times 10^{-3}) = 0.05s\,\Omega$

$Z_4 = 1/sC = 1/j(5000 \cdot 1\times10^{-6}) = 10^6/s\,\Omega$

$$\frac{V_o - V_g}{1000} + \frac{V_o}{250 + 0.05s} + \frac{V_o s}{10^6} = 0$$

$$\frac{(V_o - V_g)(250 + 0.05s)}{1000} + V_o + \frac{V_o s(250 + 0.05s)}{10^6} = 0$$

$$(V_o - V_g)(250 + 0.05s)(1000) + (10^6)V_o + V_o s(250 + 0.05s) = 0$$

$$(250V_o + 0.05sV_o - 250V_g - 0.05sV_g)(1000) + (10^6 V_o) + 250V_o s + 0.05V_o s^2 = 0$$

$$(2.5\times10^5)V_o + 50sV_o - (2.5\times10^5)V_g - 50sV_g + (10^6)V_o + 250V_o s + 0.05V_o s^2 = 0$$

$$0.05V_o s^2 + 50sV_o + 250sV_o + (2.5\times10^5 V_o) + (10^6)V_o - 50sV_g - (2.5\times10^5)v_g = 0$$

$$V_o(s^2 \cdot (0.05) + 300s + 1.25\times10^6) = (50s + (2.5\times10^5))v_g$$

$$V_o = \frac{(50 \cdot s + (2.5\times10^5))v_g}{(s^2 \cdot (0.05) + 300s + 1.25\times10^6)} \qquad V_o = \frac{1000(s + 5000)v_g}{(s^2 + 6000s + (25\times10^6))}$$

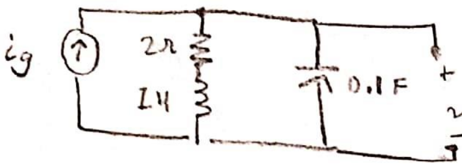
$$H(j5000) = \frac{1000(j5000 + 5000)v_g}{(j5000^2 + 6000 \cdot j5000 + (25\times10^6))}$$

$$H(j5000) = \frac{1 + j1}{j6} = \frac{1 - j1}{6} = \frac{\sqrt{2}}{6}\angle -45°$$

$$V_{oss} = (120)\frac{\sqrt{2}}{6}\cos(5000t + (30° - 45°))$$

$$\boxed{V_{os} = 20\sqrt{2}\cos(5000t - 15°)}$$

2. Assesment Problem #13.12



$H(s) = \frac{I_{out}(s)}{I_{in}(s)}$

$Z_1 = 2\Omega$

$Z_2 = sL = s$

$Z_3 = 1/sC = 10/s$

$i_g = 10\cos(4t)$ A

[How do I get the Transfer func?]

$$H(s) = \frac{10(s+2)}{(s^2+2s+10)}$$

$$H(j4) = \frac{10(j4+2)}{((j4)^2+2(j4)+10)} = \frac{20+40j}{-16+8j+10} = \frac{20+40j}{-6+4j}$$

$\frac{44.72 \angle 63.43}{7.21 \angle 33.69}$ · [Where does the denominator go???]

$\boxed{V_{out} = 44.72\cos(4t - 63.43°)}$

3. Problem #13.78 prob #13.79 in 10^{th}

linear time-invariant circuit

$$H(s) = \frac{I_o}{I_g} = \frac{125(s+400)}{s(s^2+200s+10^4)}$$

If $i_g = 80\cos 500t$ A, what is the steady-state expression for i_o

$$H(j\omega) = \frac{125(j\omega+400)}{(j\omega)((j\omega)^2+200(j\omega)+10^4)}$$

$$= \frac{125(j\omega+400)}{(j\omega(-\omega^2+200j\omega+10^4)}$$

$$H(j500) = \frac{125((j500)+400)}{(j(500))((-500^2)+200(j500))+10^4)}$$

$$H(j500) = \frac{125(640.31\angle 51.34^\circ)}{500\angle 90^\circ(260000\angle 157.38^\circ)} = \frac{80038.75\angle 51.34}{1.3\times10^8\angle 247.38^\circ}$$

$$H(j500) = 6.1568\times10^{-4}\angle -196.04$$

$$i_{out} = (6.1568\times10^{-4})(80)\cos(500t-196.04^\circ)\,A$$

$$\boxed{i_{out} = (0.049)\cos(500t-196.04^\circ)\,A}$$

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4. Problem # 13.79 Altered # 13.78 in 10^{th} edition

The transfer function for a linear time-invariant circuit is

$$H(s) = \frac{V_o}{V_g} = \frac{4(s+3)}{s^2+8s+41}$$

$V_g = 40\cos(3t)\,V$

$$H(j\omega) = \frac{4(j\omega+3)}{(j\omega)^2+8j\omega+41} = \frac{4j\omega+12}{-\omega^2+8j\omega+41}$$

$$H(3j) = \frac{4j(3)+12}{-(3j)^2+8j(3)+41} = \frac{12j+12}{9+24j+41} = \frac{12+12j}{50+24j}$$

$$H(\;\;) \quad \frac{16.97\angle 45^\circ}{55.46\angle 25.64} = 0.306\angle 19.33^\circ$$

$V_{out} = (40)(0.306)\cos(3t + 19.33^\circ)$

$$\boxed{V_{out} = 12.239\cos(3t + 19.33^\circ)}$$

5 Problem # 13.80 Prob # 13.80 in 10^{th} edition

When an input Voltage of $30u(t)$ V is applied to a circuit the response is known to be

$V_o = (50e^{-8000t} - 20e^{-5000t})\,u(t)$ V

What will the steady state response be if

$V_g = 120\cos(6000t)$ V

L-T

$30u(t)\,V = 30/s\ V$

$$V_o = \left(\frac{50}{(s+8000)} - \frac{20}{(s+5000)}\right) V$$

$$H(s) = \frac{\left(\frac{50}{(s+8000)} - \frac{20}{(s+5000)}\right) V}{\frac{30}{s}} = s\left(\frac{(50s+250000)-(20s+160000)}{30(s+8000)(s+5000)}\right)$$

$$= s\left(\frac{(30s+90000)}{30(s+8000)(s+5000)}\right)$$

$$H(s) = \frac{s(s+3000)}{(s+8000)(s+5000)}$$

$$H(j\omega) = \frac{(j\omega)((j\omega)+3000)}{(j\omega+8000)(j\omega+5000)} \Rightarrow \frac{(j6000)((j6000)+3000))}{((j6000)+8000)+((j6000)+5000)}$$

$$H(j6000) = \frac{-36+j18}{4+j75} = \frac{40.249\angle 153.434^\circ}{78.102\angle 87.064^\circ}$$

$H(j6000) = 0.515\angle 66.37^\circ$

$V_{out} = (0.515)(120)\cos(6000t + 66.37^\circ)$

$$\boxed{V_{out} = 61.84\cos(6000t + 66.37^\circ)}$$