1. (12 pts) a) Find the poles (numbers) of the following transfer function:

\[ H(s) = \frac{s^2 + \frac{1}{R(C_1 + C_2)}s + \frac{1}{LC_1}}{s^2 + \frac{R}{L}s + \frac{1}{LC_1}} \]

Where:
- \( R = 50 \text{Ω} \)
- \( L = 8 \text{mH} \)
- \( C_1 = 0.2 \text{µF} \)
- \( C_2 = 0.1 \text{µF} \)

b) This system represented by this transfer function is: (circle one)
   i) underdamped
   ii) critically damped
   iii) overdamped
   iv) impossible to tell

c) What value of \( C_1 \) would make this system critically damped?

2. (18 pts) a) Find: \( V_1 \) & \( I_2 \)

b) \( I_S \) Supplies how much power to the circuit?

3. (18 pts) The switch has been open for a long time and is closed (as shown) at time \( t = 0 \).

Find the complete expression for \( v_C(t) \).

4. (14 pts) a) Find the s-type transfer function of the circuit shown.

\( I_{\text{in}} \) is the input and \( V_O \) is the "output".

You MUST show work to get credit.

Simplify your expression for \( H(s) \) so that the denominator is a simple polynomial in standard form.

**Hint:** The "output" is a voltage and the input is a current. What is voltage over current?

\( H(s) = ? \)

b) How many zeroes does the transfer function have?
6. (34 pts) You have two input voltages to work with. A 1V battery and the waveform (at right).

\[ V_B := 1 \cdot V \]

The problems below are op-amp design problems. The answer should be a schematic of a circuit showing the values of all the parts. Use reasonable resistor values (in the 100\(\Omega\) to 1 M\(\Omega\) range). Also show how one or both of the sources are hooked up to your circuit. Most circuits won’t need both.

a) Design a circuit which will output the waveform at right.

b) Design a circuit which will output the waveform at right.

c) Design a circuit which will output the waveform at right.

d) Design a circuit which will output the waveform at right. Hint: Think differentiation.

e) Assume all of these circuits are built using one LM324 quad opAmp IC (the one you used in the lab). What is the minimum \(\pm\) supplies you should use to power this IC (Integrated Circuit)?
7. (28 pts) A transistor is used to control the current flow through an inductive load (in the dotted box, it could be a relay coil or a DC motor).

a) Assume the switch has been open for a long time and the transistor is in the active region. Find the following:

\[ I_L = ? \quad V_{CE} = ? \quad P_Q = ? \]

b) Was the transistor actually operating in the active region? yes no circle one yes

How do you know? (Specifically show a value which is or is not within a correct range.)

c) When the switch is open, you would like transistor \( Q_2 \) to saturate. What minimum \( \beta_2 \) would be required to achieve saturation?

d) Unfortunately, you can't find a replacement \( Q_2 \). So \( \beta_2 = 25 \)

Find the maximum value of \( R_2 \), so that transistor \( Q_2 \) will be in saturation.

Use this value of \( R_2 \) for the remainder of the problem

e) When the switch is closed, you would like transistor \( Q_1 \) to saturate. What minimum \( V_{BB} \) would be required to achieve saturation? \( \beta_1 = 80 \)

f) The diode in this circuit conducts a significant current:

A) never. B) when the switch opens. C) whenever the switch is open. D) when the switch closes. E) whenever the switch is closed. F) always. (circle one)

g) \( R_2 \) is that found in part c). \( \beta_1 \) is that found in part d). The switch is opened and closed a few times. What is the maximum diode current you expect. (Answer 0 if it never conducts.)
8. (20 pts) In the circuit shown, use the constant-voltage-drop model.

a) Assume that diode $D_1$ does NOT conduct.
Assume that diode $D_2$ does conduct.

Find $I_{R1}$, $I_{R2}$, $I_{R3}$, & $I_{V2}$, based on these assumptions.
Stick with these assumptions even if your answers come out absurd. Hint: think in nodal voltages.

$I_{R1} = \ ?$  $I_{R2} = \ ?$  $I_{R3} = \ ?$  $I_{V2} = \ ?$  

b) Based on your numbers above, does it look like the assumption about $D_1$ was correct?  yes  no  (circle one)

How do you know?  (Specifically show a value which is or is not within a correct range.)

c) Based on your numbers, does it look like the assumption about $D_2$ was correct?  yes  no  (circle one)

How do you know?  (Specifically show a value which is or is not within a correct range.)

10. (16 pts) A voltage waveform is applied to the circuit shown. Accurately draw the diode current waveform ($i_d$) you expect to see. Label important times and current levels.
5. (20 pts) The transformer shown in the circuit below is ideal. It is rated at 480/120 V, 1.2 kVA, 60 Hz. All values are RMS unless specified otherwise.

Find the following:

a) The primary current (magnitude). \( |I_1| = ? \)

b) The secondary current (magnitude). \( |I_2| = ? \)

c) The secondary voltage (magnitude). \( |V_2| = ? \)

d) The complex power (P and Q) used by the load. \( S_L = ? \)

e) Is this transformer operating within its ratings? Show your evidence.

9. Do you want your grade and scores posted on the Internet? If your answer is yes, then provide some sort of alias: ____________________________________________

otherwise, leave blank

Folder number ___________

The grades will be posted on line in pdf form in alphabetical order under the alias that you provide here. I will not post grades under your real name. It will show the homework, lab, and exam scores of everyone who answers here.

Answers

1. a) \( 3.125 \pm 24800 \cdot j \) b) i) c) 12.8 \( \mu \)F

2. a) 9-V 112-mA b) -720-mW

3. 15-V - 7-V \( e^{1.5 \cdot ms} \)

4. a) \( \frac{R_2 \cdot s^2 + \left( \frac{R_2 \cdot R_1}{L} + \frac{1}{C} \right) \cdot s + \frac{R_1}{L \cdot C}}{s^2 + \left( \frac{R_2 + R_1}{L} \right) \cdot s + \frac{1}{L \cdot C}} \) b) 2

5. a) 2.67-A b) 10.7-A c) 53.4-V d) (456 + 342-j) VA

6. a) \( 8 \cdot R \)

b) \( \pm 1 \cdot V \)

c) \( \pm 13 \cdot V \)

d) \( R := \frac{6}{C \cdot 1500} \)

e) \( \pm 13 \cdot V \)

7. a) 1.49-A 2.01-V 3-W b) yes 2.01-V > 0.2-V
c) 40.2 d) 44.8-\( \Omega \) e) 2.04-V f) D) g) 2.4-A

8. a) 10-mA 35-mA 20-mA 10-mA b) no 1.7-V > 0.7V
c) no -15-mA < 0

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