Examination Rules

1. All books, notes, and personal items (with the exception of pencils, eraser, calculator, TEN sheets of unmarked scratch paper, and ladies' purses) must be left in the back of the room.

2. The examination is Closed Book, Closed Note, and Closed Reference.

3. Problems on this examination must have sufficient information provided in order for the grader to be able to verify the correctness of the answer that is being provided. Where discrete intermediate data is requested, this data will be used to accept the answer(s) to the problem and to determine the amount of part credit that will be given in case the final answer(s) is/are incorrect. Be careful to write all information clearly and legibly.

4. All answers must be placed in the indicated space for a problem to be eligible for grading.

5. The examination must be submitted to the examination proctor prior to 8:15 p.m to be graded.

6. Academic misconduct (i.e. plagiarism or cheating) will not be tolerated. Any suspected instance of academic misconduct will be investigated thoroughly. Any student involved in academic misconduct will be prosecuted to the full extent allowed under university policy. This penalty will include an automatic grade of “F” in the course without the opportunity for withdrawal. If the offense is the second offense at UAB, permanent dismissal from UAB will result.

7. No student may leave his/her seat without the permission of the examination proctor unless in the process of submitting the examination for grading and leaving the room.

I have read and understand the above stated examination rules.

____________________________________
Signature

____________________________________
PRINTED NAME (FIRST, M.I., LAST)  STUDENT NUMBER
1. [20 Points] A positive-sequence, balanced three-phase wye-connected source supplies power to a balanced, wye-connected load. The magnitude of the line voltages is 150 Volt rms. If the load impedance per phase is $36 + j12 \, \Omega$, determine the line current $I_{lb}$ if the angle of $V_{an}$ is $0^\circ$.

   $I_{lb} = 2.282 \text{ Ampere}_{\text{ RMS}}$

2. [20 Points] A balanced, three-phase source serves the following loads.
   Load #1: 48 kVA at 0.90 pf lagging
   Load #2: 24 kVA at 0.75 pf lagging
The line voltage at the load is 208 Volts rms at 60 Hz. Determine the power factor of the load.

   Load Power Factor = 0.8570 lagging

3. [20 Points] The following loads are served by a balanced, three-phase source.
   Load #1: 18 kVA at 0.80 pf lagging
   Load #2: 8 kVA at 0.80 pf leading
   Load #3: 12 kVA at 0.75 pf lagging
Find the per phase impedance of the three combined loads if the load voltage is 208 Volts rms.

   $Z_{Load} = 3.945 \angle 25.065^\circ \, \Omega$

4. [10 Points] A series RLC circuit has a resistance of $5 \, \Omega$, a resonant frequency of 100 kHz, and a bandwidth of 1 kHz. Find the values of the inductance and the capacitance.

   $L = 795.8 \, \mu \text{H}$
   $C = 3.183 \, \mu \text{F}$

5. [10 Points] A parallel RLC circuit, which is driven by a variable-frequency 10-Amp source, has the following parameters: $R = 100 \, \Omega$, $L = 0.5 \, \text{mH}$, and $C = 20 \, \mu \text{F}$. Find the bandwidth of the circuit. BE SURE TO SPECIFY UNITS.

   $BW = \frac{500 \text{ rad/sec}}{}$

6. [20 Points] Determine the voltage transfer function $V_0(s)/V_i(s)$ as a function of $s$ for the network shown below.

   
   $V_0(s)/V_i(s) = \frac{(R_1LC) e^{Ls} + (R_1R_2C + L)e^s + (R_2)}{(R_1LC)e^{Ls} + (R_1R_2C + L)e^s + (R_1 + R_2)}$
1. [20 Points] A positive-sequence, balanced three-phase wye-connected source supplies power to a balanced, wye-connected load. The magnitude of the line voltages is 150 Volt rms. If the load impedance per phase is $36 + j12 \, \Omega$, determine the line current $I_{bb}$ if the angle of $V_{an}$ is $0^\circ$.

$$I_{bb} = \frac{2282}{\sqrt{3}} \text{ Ampere}_\text{rms}$$

2. [20 Points] A balanced, three-phase source serves the following loads.
   - Load #1: 18 kVA at 0.80 pf lagging
   - Load #2: 8 kVA at 0.80 pf leading

   The line voltage at the load is 208 Volts rms at 60 Hz. Determine the power factor of the load.

   Load Power Factor = $0.9608 \text{ lagging}$

3. [20 Points] The following loads are served by a balanced, three-phase source.
   - Load #1: 48 kVA at 0.90 pf lagging
   - Load #2: 24 kVA at 0.75 pf leading
   - Load #3: 12 kVA at 0.75 pf lagging

   Find the per phase impedance of the three combined loads if the load voltage is 208 Volts rms.

   $$Z_{Load} = 1.818 / 10.480^\circ \, \Omega$$

4. [10 Points] A series RLC circuit has a resistance of $10 \, \Omega$, a resonant frequency of 100 kHz, and a bandwidth of 1 kHz. Find the values of the inductance and the capacitance.

   $$L = \frac{1.591}{m} \text{ Henrys}$$
   $$C = \frac{1.591}{n} \text{ Farads}$$

5. [10 Points] A parallel RLC circuit, which is driven by a variable-frequency 10-Amp source, has the following parameters: $R = 500 \, \Omega$, $L = 0.5 \, \text{mH}$, and $C = 20 \, \mu\text{F}$. Find the bandwidth of the circuit. BE SURE TO SPECIFY UNITS.

   $$BW = 100 \text{ rad} / \text{sec}$$

6. [20 Points] Determine the voltage transfer function $V_0(s)/V_i(s)$ as a function of $s$ for the network shown below.

   $$V_0(s)/V_i(s) = \frac{R_2}{(R_2L)^2 + (R_2R_4C + L)s + (R_4 + R_1)}$$
0. [Key A] & [Key B]

\[ |V_L| = 150 \ \text{V}_{\text{RMS}} \rightarrow |V_P| = \frac{150}{\sqrt{3}} \ \text{V}_{\text{RMS}} \]

\[ V_{b_n} = \frac{150}{\sqrt{3}} \angle -120^\circ \]

\[ I_{bb} = \frac{V_{b_n}}{Z} = \frac{150}{\sqrt{3}} \angle -120^\circ}{(36 + j12)} = \frac{2.282}{(A \ \text{rms})} \angle 138.9^\circ \]
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Pose 2/7

2) Key A

\[ S_T = S_1 + S_2 \]

\[ S_1 = 48K \angle 25.84^\circ \text{ VA} \]
\[ S_2 = 24K \angle 41.41^\circ \text{ VA} \]

\[ S_T = 71.41K \angle 31.01^\circ \text{ VA} \]

\[ \text{p.f.} = \cos (\angle S_T) = 0.8570 \]

2) Key B

\[ S_T = S_1 + S_2 \]

\[ S_1 = 18K \angle 36.87^\circ \text{ VA} \]
\[ S_2 = 8K \angle -36.87^\circ \text{ VA} \]

\[ S_T = 21.65K \angle 16.09^\circ \text{ VA} \]

\[ \text{p.f.} = \cos (\angle S_T) = 0.9608 \]
S_1 = 18\,\text{K} \angle 36.87^\circ \, \text{VA} \\
S_2 = 8\,\text{K} \angle -36.87^\circ \, \text{VA} \\
S_3 = 12\,\text{K} \angle 41.41^\circ \, \text{VA}

S_T = S_1 + S_2 + S_3 = 32.898\,\text{K} \angle 25.065^\circ \, \text{VA}

S_{\text{ph}} = S_0 = \frac{S_T}{3} = 10.966\,\text{K} \angle 25.065^\circ \, \text{VA}

V_{AN} = 208\,\text{LeV} \, V_{\text{rms}}, \quad S = V_2^* \Rightarrow I_{aA} = 52.721\,\text{LeV} \angle 25.065^\circ \, \text{A rms}

V_{AN} = I_{aA} Z_Y \Rightarrow Z_Y = 3.945\,\angle 25.065^\circ \, \Omega

Note: (1) \( \theta_V \) disappears from the answer
     (2) if we assume that the 208 LeV means
         \( V_{AB} = V_{LL} \), then \( Z_Y \) is \( \frac{1}{3} \) the value given.

S_1 = 48\,\text{K} \angle 25.84^\circ \, \text{VA} \\
S_2 = 24\,\text{K} \angle -41.40^\circ \, \text{VA} \\
S_3 = 12\,\text{K} \angle 41.40^\circ \, \text{VA} \\
S_T = 71.39\,\text{K} \angle 10.48^\circ \, \text{VA} \\
I_{aA} = 114.4\,\text{LeV} \angle 10.48^\circ \, \text{A rms}

Z_Y = 1.818\,\angle 10.48^\circ \, \Omega
Key A

\[ Q = \frac{\omega_o}{B\omega} = \frac{100\,kH}{(2\pi)\times1\,kH} = 100. \]

\[ R_s = \frac{1}{\omega_o \cdot C R} \Rightarrow C = \frac{1}{\omega_o \cdot R_s} = \frac{1}{(100\,kHz)(2\pi)(5)(100)} \]

\[ C = 3.183 \, \text{nF} \]

\[ Q_s = \frac{\omega_o \cdot L}{R} \Rightarrow L = \frac{Q_s R}{\omega_o} = \frac{(100)(5)}{(100\,kHz)(2\pi)} = 795.77 \, \text{mH} \]

Key B

\[ Q = \frac{\omega_o}{B\omega} = \frac{100\,kHz}{(2\pi)\times1\,kHz} = 100. \]

\[ C = \frac{1}{\omega_o \cdot R_s} = \frac{1}{(100\,kHz)(2\pi)(10)(100)} = 1.591 \, \text{nF} \]

\[ L = \frac{Q_s R}{\omega_o} = \frac{(100)(10)}{(100\,kHz)(2\pi)} = 1.5915 \, \text{mH} \]
\[ w_0 = \frac{1}{\sqrt{LC}} = 10K \text{ rad/sec} \]

\[ Q_{\parallel} = w_0 RC = 20 \]

\[ BW = \frac{w_0}{Q} = \frac{10K \text{ rad/sec}}{20} = \frac{500 \text{ rad/sec}}{} \]

\[ w_0 = \frac{1}{\sqrt{LC}} = 10K \text{ rad/sec} \]

\[ Q_{\parallel} = w_0 RC = 100 \]

\[ BW = \frac{w_0}{Q} = \frac{10K \text{ rad/sec}}{100} = \frac{100 \text{ rad/sec}}{} \]

**Side Note:**

**Q\text{ Series vs. Q\text{ Parallel}**:

\[ Q_{\text{ser}} = \frac{1}{Q_{\parallel}} = \frac{w_0L}{R} = \frac{1}{w_0 RC} = \frac{1}{R \sqrt{L/C}} \]

**But**

\[ w_0 = \frac{1}{\sqrt{LC}} \text{ and } Q = \frac{w_0}{BW} \text{ always} \]
By Voltage Division:

\[
\frac{V_0}{V_i} = \frac{Z_2}{Z_1 + Z_2}
\]

\[
Z_1 = R_1 \parallel \frac{1}{C_2} = \frac{R_1}{R_1 C_2 + 1}
\]

\[
Z_2 = R_2 + L_2
\]

\[
\frac{V_0}{V_i} = \frac{R_2 + L_2}{\frac{R_1}{R_1 C_2 + 1} + R_2 + L_2}
\]

\[
= \frac{(R_2 + L_2)(R_1 C_2 + 1)}{R_1 + (R_2 + L_2)(R_1 C_2 + 1)}
\]

\[
\frac{V_0}{V_i} = \frac{(R_1 L C) Z^2 + (R_1 R_2 C + L) Z + (R_2)}{(R_1 L C) Z^2 + (R_1 R_2 C + L) Z + (R_1 + R_2)}
\]
\[ Z_1 = R_1 + L \frac{1}{\omega^2} \]
\[ Z_2 = \frac{R_2}{\frac{1}{\omega^2} + \frac{R_2}{C_2}} \]

\[
\frac{V_o}{V_i} = \frac{\frac{R_2}{R_2 C_2 + 1}}{R_1 + L \frac{1}{\omega^2} + \frac{R_2}{R_2 C_2 + 1}}
\]

\[
= \frac{R_2}{(R_1 + L \frac{1}{\omega^2})(R_2 C_2 + 1) + R_2}
\]

\[
\frac{V_o}{V_i} = \frac{R_2}{(R_2 L C \omega^2 + (R_1 R_2 C + L) \omega + (R_1 + R_2))}
\]