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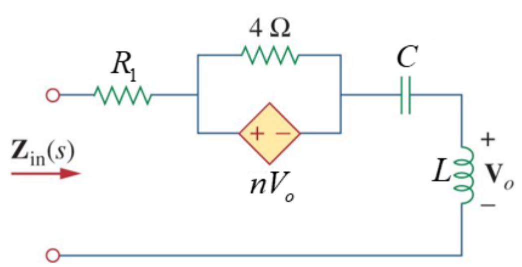
1. (17 points)

[17 marks, approx 15 mins] For the circuit in the figure below, find the input impedance, $Z_{in}(s)$, as a function of s, the Laplace variable. (a) Do a Bode amplitude plot and determine the frequency at which Z_{in} is minimum, ω_o, in rad/s. On the Bode amplitude plot, determine the +3 dB frequencies, (b) ω_1 and (c) ω_2, also in rad/s. Compute (d) the bandwidth, in rad/s; and (e) the quality factor. Then, scale the circuit so that the circuit uses 10 $k\Omega$ resistors instead, and so that the minimum impedance occurs at 20 $krad/s$. After scaling, what will be the values of the reactive elements, (f) L and (g) C?. (N.B. scaling won't affect the dependent source coefficient n.) The reactive element values are $L = 7.8$ H, and $C = 0.6\,F$. The resistor $R_1 = 4\,\Omega$. The dependent source coefficient $n = 3.5$.

Figure corresponding to Question 1 of this final exam.



DO NOT GUESS ANSWERS. The right answer without the correct procedure is still an invalid response.

(a) $\omega_o =$ ____ **rad/s**

(b) $\omega_1 =$ ____ **rad/s**

(c) $\omega_2 =$ ____ **rad/s**

(d) $Bandwidth =$ ____ **rad/s**

(e) $Quality\ factor =$ ____ **no units**

(f) $L_{new} =$ ____ **H**

(g) $C_{new} =$ ____ **F**

Answer(s) submitted:

- `0.2179068`
- `0.1542662`
- `0.3078016`
- `0.153535`
- `1.419262`
- `0.2124591`
- `0.000000002614882`

(correct)

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2. (9 points)

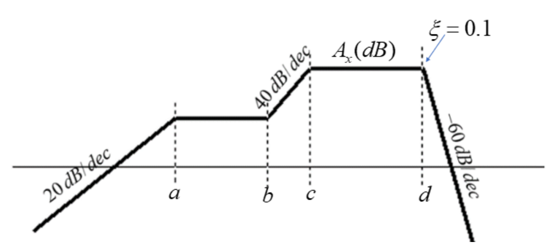
[9 marks, approx 7 minutes.] A transfer function H(s) is approximated by the Bode amplitude plot in the figure below. Observe that there is a damping factor associated with the frequency 'd' in the figure. A student concludes that the transfer function can be written as

$$H(s) = \frac{ks(s+b)^2}{(s+a)(s+c)^2(s^2+ms+n)}$$

If you agree with the student, compute and report the constant 'k' on the numerator. If you don't agree with the student, write the correct transfer function on your procedure-page (that you will scan and upload as a PDF), and compute and report below in the entry box the value of the correct 'k' (the one for your transfer function). The values for your question are: $a = 900,\ b = 1550\ c = 2800\ d = 12000\ m = 2400\ n = 1.44 \times 10^8$ All in rad/s except the last two. The decibels level at the highest plateau is $A_x = -176.596\,dB$.

N.B. If you are entering results in scientific notation, example 1.234 x 10^(-3), use an uppercase E to enter 1.234E-3, never type 1.234e-3.

Bode amplitude plot of a transfer function H(s)



The right value for the constant k = ____

Answer(s) submitted:

- `0.001596992416`

(incorrect)

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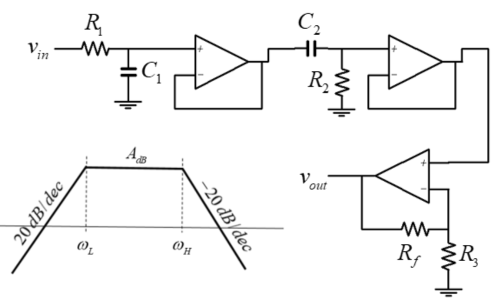
3. (8 points)

[8 marks, approx 5 mins] Select the values of the capacitors for the bandpass filter in the top right part of the figure, so that its Bode amplitude plot (frequency response) corresponds to the dB-versus-rad/s-plot on the lower left corner of the figure below. All op amps are ideal. $R_1 = R_2 = R_3 = 13\ k\Omega$ (that is, all those three resistors have the same value.) Also, if the bandpass gain is to be (the decibels on the plateau) $A_{dB} = 14\ dB$, what should be the value of the feedback resistor R_f in kilo ohms? For your question, $\omega_L = 320\ rad/s$ and $\omega_H = 16000\ rad/s$.

An active bandpass filter and its Bode frequency response



$C_1 =$ ___ **nF**

$C_2 =$ ___ **nF**

$R_f =$ ___ $k\Omega$

Answer(s) submitted:

- `4.807692`
- `240.3846`
- `52.1543403175`

(correct)

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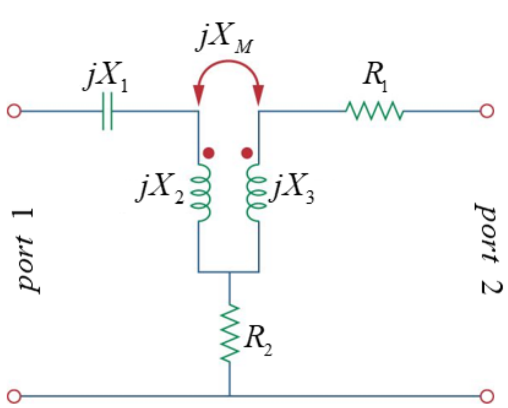
4. (16 points)

[16 marks, approx. 15 mins.] For the two-port network in the figure below, compute and report the hybrid parameters. For your question, $X_1 = -5\ \Omega,\ X_2 = 3\ \Omega\ X_3 = 8\ \Omega\ X_M = 6\ \Omega\ R_1 = 2\ \Omega, R_2 = 16\ \Omega$.

Two port network to find the hybrid parameters.



h11 = ___ + j___

h12 = ___ + j___

h21 = ___ + j___

h22 = ___ + j___

Answer(s) submitted:

- `0.04639175`
- `-0.02061855`
- `-0.783505154639`
-
- `-3.7731958`
- `0.237113402062`
-
-

(score 0.25)

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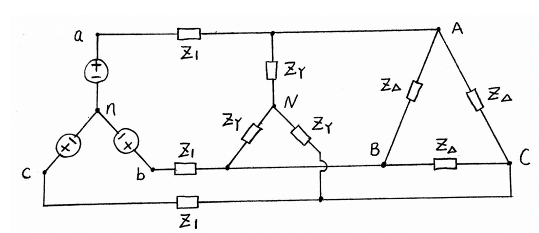
5. (20 points)

A balanced three-phase system has a distribution wire with impedance $Z_1 = 10.5 + j14\,\Omega$ per phase. The system supplies two three-phase loads that are connected in parallel. The first is a balanced wye-connected load that absorbs a total $S_a = 350\,kVA$ apparent power at a power factor $pf = 0.8$ lagging. The second load is a balanced delta-connected load with impedance of $Z_\Delta = 21 + j16.8\,\Omega$ per phase. The magnitude of the line voltage at the loads is $V_{line}^{load} = 2400\,V_{rms}$. Find:

(a) Magnitude of the line voltage at the source: ___ V_{rms}

(b) Total complex power of the two loads: ___+j___ kVA

Three phase balanced system with two loads in parallel.



Answer(s) submitted:

- `9636.48998611`
- `781.74216`
- `611.39372`

(score 0.666667)

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6. (15 points)

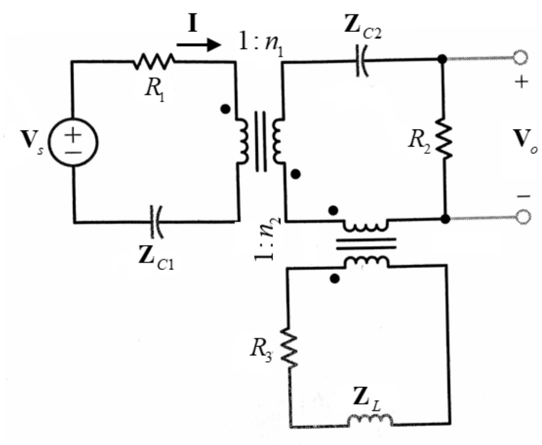
The circuit below contains two ideal transformers, where $\mathbf{V_s} = \mathbf{35\angle 0^o}$ V, $R_1 = 6\,\Omega$, $R_2 = 5\,\Omega$, $R_3 = 7\,\Omega$, $\mathbf{Z_{c1}} = -\mathbf{j6}$■, $\mathbf{Z_{c2}} = -\mathbf{j5}$■, and $\mathbf{Z_L} = \mathbf{j8}$■. The turns ratios are $n_1 = 0.5$, and $n_2 = 2$.

Find:

(a) Current I at the source: ___ A with a phase: ___ deg.

(b) Voltage $\mathbf{V_o}$: ___ V with a phase: ___ deg.

Circuit with two ideal transformers.



Answer(s) submitted:

- `0.2039577`
- `-36.469234`
- `2.039577170`
- `143.53076561`

(correct)

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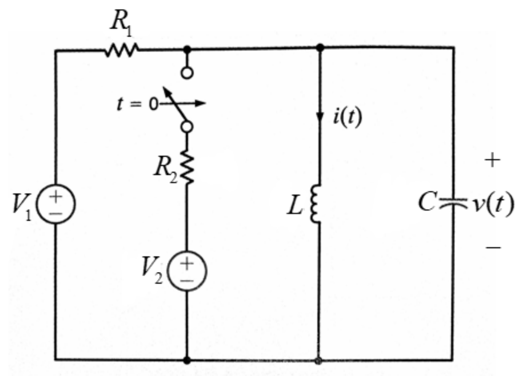
7. (15 points)

In the second-order circuit below, $V_1 = 12\,V$, $V_2 = 24\,V$, $R_1 = 15\,\Omega$, $R_2 = 7\,\Omega$, $L = 1.1\,H$, and $C = 0.02\,F$. Find the answers in (a) through (e) below:

Second Order Circuit where the switch closes at t = 0.



(a) $v(0^+) =$ ___ V.

(b) $i(0^+) =$ ___ A.

(c) $\dfrac{dv}{dt}(0^+) =$ ___ V/s.

(d) $\dfrac{di}{dt}(0^+) =$ ___ A/s.

(e) $v(\infty) =$ ___ V.

(f) $i(\infty) =$ ___ A.

Answer(s) submitted:

- `0`
- `4/5`
- `171.428571`
- `0`
- `0`
- `4.228571`

(correct)